California's Flood Future

Recommendations for Managing the State's Flood Risk

Attachment F: Flood Hazard Exposure Analysis

FINAL November 2013

California's Flood Future is provided to help inform local, State, and Federal decisions about policies and financial investments to improve public safety, foster environmental stewardship, and support economic stability

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PUBLIC SAFETY ENVIRONMENTAL STEWARDSHIP ECONOMIC STABILITY

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STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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Attachment F: Flood Hazard Exposure Analysis

November 2013

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

UNITED STATES ARMY CORPS OF ENGINEERS
FLOOD PLAIN MANAGEMENT SERVICES PROGRAM

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Acronyms and Abbreviations

ACE	Annual Chance Exceedance
CalEMA	California Emergency Management Agency
CEAC	County Engineers Association of California
cm	centimeter
CNDDB	California Natural Diversity Database
CNRA	California Natural Resources Agency
CVFPP	Central Valley Flood Protection Plan
CWP	California Water Plan
Delta	Sacramento-San Joaquin Delta
DoD	U.S. Department of Defense
DWR	California Department of Water Resources
EAD	expected annual damage
EM	Engineer Manual
ER	Engineering Regulation
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
Flood Future Report	*California's Flood Future: Recommendations for Managing the State's Flood Risk*
GIS	Geographic Information System
HAZUS	Hazards United States
HEC-FDA	Hydrologic Engineering Center-Flood Damage Analysis
IFM	Integrated Flood Management
IRWM	Integrated Regional Water Management
IWM	Integrated Water Management
OMRR&R	operation, maintenance, repair, rehabilitation, and replacement
QA/QC	Quality Assurance/Quality Control
SFMP	Statewide Flood Management Planning
TM	Technical Memorandum
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

Acronyms and Abbreviations

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1.0 Introduction

1.1 Background

California is at risk for catastrophic flooding. All 58 California counties have experienced at least one flood event with significant consequences in the last 20 years, resulting in loss of life and billions of dollars in damages. This report, *California's Flood Future: Recommendations for Managing the State's Flood Risk* (Flood Future Report), is the first product of the Statewide Flood Management Planning (SFMP) Program. The Program was developed under the FloodSAFE Initiative to expand California's flood management planning statewide. Specifically, the purpose of the SFMP Program is to make recommendations to inform flood management policies and investments in the coming decades by:

- Promoting a clear understanding of flood risks in California
- Garnering active support for partnerships at the local, tribal, State, and Federal levels[1]
- Coordinating with other California Department of Water Resources (DWR) planning efforts
- Identifying strategies and feasible next steps to better incorporate flood management into Integrated Water Management (IWM)
- Promoting an IWM approach for flood management solutions

The initial work of the SFMP Program was to collect information in support of the Flood Future Report, as well as to build partnerships with local flood management agencies, the County Engineers Association of California (CEAC), Federal Emergency Management Agency (FEMA), and the United States Army Corps of Engineers (USACE). Throughout the Flood Future Report, determinations about specific flood terms were made that may not represent the specific terms used by partner agencies. These are described in Textbox 1-1. A description of the Flood Future Report components, organization, and layout is provided in Appendix A.

1.2 Purpose

An important objective of the SFMP Program is to characterize current and future flood risks throughout California based on the best available information. This technical memorandum (TM), presented as Attachment F to the Future Flood Report, describes a flood hazard exposure analysis that was performed to provide insight into potential flood risks throughout the state. The flood hazard exposure analysis supplements the information presented in the Flood Future Report with a detailed description of the method and results of the analysis. This analysis is sometimes referred to as the "flood exposure analysis" in the Flood Future Report.

[1] Hereafter in this document, the mention of governmental agencies is implicit to include tribal entities.

The purpose of the flood hazard exposure analysis is to use a consistent, accurate, and reproducible method to quantify the people and property that might be harmed from flooding in California. The analysis uses a limited set of flood exposure indices, such as population and critical facilities, to describe and compare flood hazard exposure among the diverse regions of the state. This TM qualitatively describes loss of function, which is the effect that a flood event could have on the function of inundated structures and infrastructure. In addition, this attachment includes a discussion of the potential effects of future changes in population and land use, as well as future climate changes, on flood hazard exposure in California.

Textbox 1-1: Agencies Differ in Flood Terminology

One of the challenges in a multi-agency effort is resolving language and culture differences between agencies. Staff from both USACE and DWR who are responsible for developing this report have made a conscious choice to adopt certain terminology throughout the documents.

As an example, USACE has adopted ***flood risk management*** as the term to describe a broad flood program that encompasses planning, construction, and operation, maintenance, repair, rehabilitation, and replacement (***OMRR&R***). DWR executes a similar broad program, largely through its Flood Management Division. As a result, DWR uses the term ***flood management*** in much the same way USACE uses *flood risk management*.

Another term used throughout this document is ***100-year flood*** (or some other *x*-year flood). Although these terms are commonly used, both USACE and DWR prefer using ***1 percent chance flood*** (or a 1-in-100 chance event) to describe a flood that has a 1 percent chance of occurring in any given year. However, legislative language from 2007 directing DWR to undertake new planning using bond proceeds uses 100-year flood.

For Federally funded projects, the definition of operation and maintenance (***O&M)*** includes the local entity's financial obligation for OMRR&R of the implemented project. OMRR&R is a non-Federal responsibility when local, regional and/or State entities partner on a Federal project. DWR typically uses O&M to refer simply to operation and maintenance, although repair and rehabilitation are sometimes included depending on project specifics. References to O&M provided in this report include OMRR&R responsibilities when the project is a Federal/non-Federal partnership.

For this report, both agencies agreed that, although language and cultural differences remain, it is more important to focus on the shared responsibility of performing our flood risk management or flood management missions rather than the use of specific phrases not in each agency's respective culture. A glossary is included to help the reader understand specific terms used by flood professionals and those terms that are used to define specific agency missions.

1.3 Overview of TM Organization

The following sections define and characterize flood hazard exposure, summarize the statewide results of the exposure analysis performed, and describe ways to improve understanding of flood risk management statewide. Attachment F is presented in the following sections:

- Section 1: Introduction
- Section 2: 2.0 Why a Flood Hazard Exposure Analysis?
- Section 3: Flood Hazard Exposure Analysis Method
- Section 4: Results of SFMP Flood Hazard Exposure Analysis
- Section 5: Future Impacts on Exposure to Flood Hazard
- Section 6: Findings
- Section 7: References

This attachment is supported by the following technical appendices:

- Appendix A: Flood Future Report Components
- Appendix B: Analysis of Exposure to Flood Hazard, by CWP Hydrologic Region
- Appendix C: Analysis of Exposure to Flood Hazard, by County
- Appendix D: Analysis of Exposure to Flood Hazard, by U.S. Congressional District
- Appendix E: Analysis of Exposure to Flood Hazard, by State Assembly District
- Appendix F: Analysis of Exposure to Flood Hazard, by State Senate District
- Appendix G: Analysis of Exposure to Flood Hazard, by Delta Primary/Secondary Zones and Mountain Counties
- Appendix H: Analysis of Exposure to Flood Hazard, by IRWM Region
- Appendix I: Glossary

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2.0 Why a Flood Hazard Exposure Analysis?

2.1 Definition of Flood Hazard Exposure

Flood hazard exposure describes who and what may be harmed by the flood hazard. Thus, it requires a description of where the flooding occurs and what exists in that area. This study uses FEMA 100-year (1 percent Annual Chance Exceedance [ACE]) and 500-year (0.2 percent ACE) floodplains and other flood maps. These delineations of flood areas are based on frequency and thus provide information about the hazard. More information about how the floodplains were defined in this study is provided in Section 3.1.2.

The SFMP Program describes exposure using population estimates; monetary values of structures, their contents, and crops; numbers and acreage of U.S. Department of Defense (DoD) facilities and Native American tribal lands, transportation facilities, and numbers of critical facilities, all within well understood floodplain boundaries. This analysis uses a limited set of flood exposure indices to describe and compare flood hazard exposure among the diverse regions of the state.

2.2 Flood Hazard Exposure Analysis Differs from Flood Risk Analysis

The flood hazard exposure analysis is a limited representation of detailed flood risk. This section gives the analysis context by describing flood risk and its components as reflected in the analysis of flood hazard exposure.

Flood risk is the likelihood of adverse economic and life-safety consequences of flood inundation.

2.2.1 Definition of Flood Risk

Engineers, scientists, and floodplain managers define **flood risk** (or inundation risk) as the likelihood of consequences (damages) of flood inundation (resulting from an entire range of hydrologic events), including both economic and life-safety consequences. Flood risk is not simply the loss of life or damage incurred due to a single catastrophic event. Rather, flood risk characterizes the likelihood of adverse consequences for the entire range of flood events for a given impact area. *Impact area* is a term used to describe a geographic area for which risk is assessed.

Flood risk takes into account these five factors (shown in Figure F-1):

- Hazard: The cause of the harm, including its probability, extent, depth, and other characteristics (i.e., flooding and how often)
- Performance: How well the flood management system responds to the hazard (i.e., flood management system inadequacy or failure)
- Exposure: Who and what might be harmed by the hazard (i.e., who and what is flooded)

- Vulnerability: The susceptibility of people and property to harm from the hazard (i.e., how flooding adversely affects people and property)
- Consequence: The loss or damage incurred as a result of the hazard (i.e., what is the cost of the flooding in terms of lives and dollars)

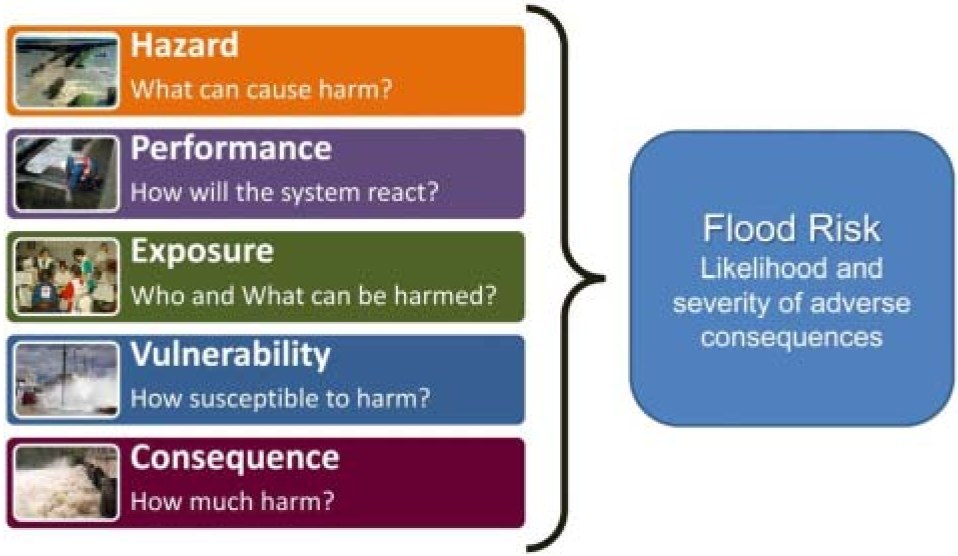

Figure F-1 Factors that Contribute to Flood Risk

Flood risk is expressed as a consequence-probability relationship. For example, when consequence is described as economic damage from flood inundation, flood risk is the probability of flood damage from various magnitudes of flooding.

The consequence-probability function can be integrated to compute an expected or most likely value of the consequence. If the probabilities are annual values, this most likely value is called the expected annual value. If the consequence considered is economic loss, the most likely value is called the expected annual damage (EAD). EAD reduction is often used as a standard for measuring the effectiveness of proposed flood management actions. This study did not compute EAD because it focuses solely on exposure, as described in the next section.

A detailed flood risk analysis, which would be necessary for a planning study by USACE and its project sponsors, is intended to identify and evaluate specific flood management measures, such as levees (including their types, locations, and dimensions). This analysis would assess flood management, economic impacts, life-safety risks, environmental impacts, and social benefits of the proposed measures. In addition, a detailed flood risk analysis would evaluate the consequences of a full range of possible flood hazards. Such a risk analysis would consider the likelihood of the flooding, the performance of existing or proposed actions and measures, current and future exposure of people and property to flooding, and the vulnerability of both.

Attachment G: Risk Information Inventory provides additional information about the analytical procedures used to compute flood risk.

2.2.2 Differences between Flood Hazard Exposure Analysis and Flood Risk Analysis

Key differences between the flood hazard exposure analysis described herein and a detailed flood risk analysis, which was not done, are provided in Table F-1.

Table F-1. Comparison of Flood Hazard Exposure Analysis and Flood Risk Analysis

Flood Hazard EXPOSURE Analysis	Detailed Flood RISK Analysis
Enables decision makers to identify and establish broad priorities for future statewide floodplain management.	Evaluates economic efficiency of alternative plans formulated to reduce flood risk at a particular location.
Uses a systematic, repeatable method to describe and compare exposure to flood hazard throughout the state's diverse regions.	Uses detailed analytical methods and procedures found in USACE guidance, such as Engineering Regulation (ER) 1105-2-100, ER 1105-2-101, and Engineer Manual (EM) 1110-2-1619 to describe flood risk in a particular location with defined conditions.[a]
Illustrates at a high level the variation in exposure to flood hazard among the state's geographic and political regions.	Describes the feasibility of a specific project, leading to identification of a recommended alternative.
Uses best currently available information and the assumptions built into that information.	Includes new model development; floodplain, topography, and bathymetric data collection; inclusion of fragility curves; population projections; and so on.
Is an assessment with a budget and study period appropriate for a high-level look at flood exposure statewide.	Would require a relatively large budget and long timeframe to identify likelihood and severity of flooding throughout the state.
Examines only two flood events—the 100-year flood and the 500-year flood. The results from this analysis could show significantly different results if flood events at different probabilities were used.	The inception of inundation could occur for flood events below the 100-year event. A detailed risk analysis takes into account exceedance probabilities of all likely flood events and should capture the inception of inundation flood events.
Quantifies a limited set of indices of exposure (who and what might get harmed)—population exposed, number and acreage of Tribal lands and DoD facilities, critical facilities exposed, depreciated replacement value of property (structures and contents), and value of crops exposed.	Accounts for factors in addition to exposure—hazard, performance, vulnerability, and consequence—to provide a detailed description of flood risk in a particular location with defined conditions, which will more accurately assess the likelihood of economic damage and loss of life.
Simplifies the description of inundation by placing people and property in one of two categories— "wet" or "dry." That is, either they are touched by floodwater or they are not.	Accounts for the complex interactions among floodwater, floodplain, property, and human occupants through the use of depth-damage relationships, evacuation modeling, depth-mortality relationships, and other functions.
Uses depreciated replacement value of structures/content, without a consideration of gradations of potential damage at different flood depths, and market value of crops (i.e., a "snapshot" of their value just prior to harvest) to describe exposure.	Accounts for seasonality of flooding in relation to crop growing cycle in the determination of crop loss. May include a broader description of economic loss, including physical and nonphysical damages, both direct and indirect. May also examine life loss and environmental and social loss/damage.
Uses only Geographic Information System (GIS) tools.	Uses other tools, such as Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA), in addition to GIS tools.
Considers only whether levees meet FEMA criteria for accreditation in most regions of the state outside the Central Valley. In an area where levees meet the criteria, the area is considered to be "dry" (not inundated). In an area where levees do not meet the criteria, the area is considered to be "wet" (inundated). Note: Within the Central Valley Flood Protection Plan (CVFPP) boundary, levee fragility curves were used in the development of the floodplains (i.e., levee performance is included in the determination of an area as "wet" or "dry").	Considers performance of structural features such as levees directly.

Notes:
[a]Referenced regulations are available upon request or can be found online at HQPublications@usace.army.mil.

2.3 Flood Hazard Exposure Analysis is Appropriate for the SFMP Program Flood Future Report

The analytical method used by the study team for assessing exposure to flood hazard is consistent with—but narrower in scope than—the method used for detailed flood risk analysis. Despite certain simplifications, the analysis of exposure to flood hazard is appropriate for this study for the following reasons:

- It provides information on potential consequences of flooding throughout the state in a consistent, systematic, repeatable manner.
- It allows for comparison of flood exposure among various areas of the state.
- It provides information adequate to identify and prioritize a broad range of flood management recommendations.
- It makes use of flood hazard and exposure information from a variety of reliable, reviewed sources, including DWR, USACE, FEMA, and local flood management agencies.
- It is a cost-effective method for gathering the information needed for inclusion in the SFMP Flood Future Report.
- It is aligned with, although not identical to, the risk analysis completed for the Central Valley Flood Protection Plan (CVFPP) project.
- It lays a firm foundation for future, more detailed, risk analyses.

On the other hand, the data and information required for a statewide risk analysis were not readily available. Risk analysis considers more than exposure, as noted previously. Because of the effort required, detailed risk analysis has been completed for a limited number of locations in the state, specifically for projects that need to evaluate the economic efficiency of flood risk reduction plans to qualify for Federal funding. A statewide flood risk analysis would be an extensive, costly, and multi-year effort. This study provides the first steps to efficiently allocate resources that are aimed at identifying and prioritizing flood management efforts.

3.0 Flood Hazard Exposure Analysis Method

The SFMP flood hazard exposure analysis method uses existing Geographic Information System (GIS) data to identify the population, property, structures, facilities, and crops located within FEMA-designated 100-year (and 500-year, where available) floodplains, 2012 CVFPP floodplains, or other best available mapping. Quantities of structures and crops exposed within the floodplain are estimated using information in the Hazards United States (HAZUS) and ParcelQuest (property and parcel information) databases. Population data were obtained from the U.S. Census and HAZUS databases. The method is designed to be consistent with flood risk analyses that were performed for the CVFPP. The CVFPP is focused on identification and investment in systemwide solutions that reduce flood risk and promote projects with an IWM approach in the Sacramento and San Joaquin valleys. This analysis provides a high-level description of statewide exposure to flood hazard. Results from the flood hazard exposure analysis are presented for different analysis regions, including statewide California Water Plan (CWP) hydrologic regions, counties, legislative and congressional districts, Sacramento-San Joaquin Delta (Delta) zones, Mountain Counties, and Integrated Regional Water Management (IRWM) regions. This attachment also qualitatively describes loss of function, which is the effect that a flood event could have on the function of inundated structures (residential, commercial, industrial, public, or others) and infrastructure, such as transportation, health and human services, water supply, wastewater treatment, utilities, energy generation, and emergency services. In addition, this attachment includes a discussion of the potential effects of future changes in population and land use and future climate change on flood hazard exposure in California.

3.1 Data

3.1.1 Data Requirements

To identify inundation exposure for people and property, ArcGIS is used to overlay floodplain maps with other types of maps (geo-referenced shapefiles such as census blocks). The basic data required for the SFMP flood hazard exposure analysis include:

- Floodplains – The extent of the flood hazard for the 100-year and 500-year events.
- Population – The total population exposed to the flooding
- Structures – The total number and depreciated replacement value of structures and content exposed to the flooding, including residential, commercial, industrial, and public
- Critical Facilities – The number of certain types of facilities exposed to flooding, including schools, fire and police stations, hospitals, utilities, transportation facilities, and others

- DoD Facilities – Number and acreage of DoD facilities exposed to flooding
- Crops – The market value (yield multiplied by price) of crops exposed to flooding, including grain and hay; rice; field crops; pasture crops; truck, nursery, and berry crops; deciduous fruits and nuts; citrus and subtropical crops; and vineyard crops
- Native American Tribal Lands – Number and acreage of tribal lands exposed to flooding

3.1.2 Sources of Data

This SFMP analysis defines people and property as being exposed if they are located within the 500-year floodplain or 100-year floodplain. The floodplain is defined in one of three ways based on the source of the data—(1) FEMA floodplains, (2) floodplains defined (or refined) by USACE flood maps, or (3) the CVFPP floodplains, as defined by the CVFPP on October 4, 2011. This distinction among floodplains is relevant only in terms of the sources of data about the extent of the flood hazard. Use of the CVFPP floodplains within the CVFPP boundary ensures alignment of this SFMP study and the CVFPP. For this analysis, the CVFPP boundary is defined as the outer limits of the CVFPP impact areas used for the flood risk analysis.

The data sources used in this study are described below. Data that were also used for the CVFPP are noted.

- Floodplains
  - Where they were available, the SFMP used detailed 100-year and 500-year floodplains developed for the CVFPP flood risk analysis impact areas. The SFMP team obtained the draft CVFPP floodplains on October 4, 2011. The CVFPP floodplains were based on the *Sacramento and San Joaquin River Basins, California, Comprehensive Study* (USACE, 2002) floodplains and modified by CVFPP to reflect current hydrologic, hydraulic, and geotechnical information. For the SFMP analysis, the Yolo, East Side, Upper Sacramento, Mariposa, Sutter, and Tisdale bypasses were added to the CVFPP floodplains. Floodplains for the Stockton area were developed for the CVFPP after October 4, 2011, and were not available at the time of the SFMP analysis.
  - Outside the CVFPP boundary, the SFMP used FEMA Flood Insurance Rate Maps (FIRMs) (FEMA, 2013)[2], supplemented by five floodplain maps provided by the USACE following their standards given by Engineering Regulation (ER) 1105-2-101 and other guidance, to define 500-year and 100-year floodplains. It should be noted that 500-year floodplains were not available for some areas; however, this occurs only in small, sparsely populated areas of the state and will have a minimal effect on the results of the analysis.

[2] The 100-year floodplain used in the analysis includes regions of Special Flood Hazard Area with FEMA flood zone designations A, AE, AH, AO, A99, V, and VE and other regions with a 1 percent annual chance of flooding. The 500-year floodplain includes these same regions, plus those with FEMA flood zone designation X shaded and other regions with a 0.2 percent annual chance of flooding.

    - Figure F-2 shows the floodplains used in the analysis.

- Population – The SFMP used 2000 census data available in FEMA's HAZUS model. Census data for 2010 were available for the SFMP; however, to align this study with the CVFPP, 2000 census data were used (FEMA, 2011). (The 2010 census data were not available when the CVFPP analysis was started.)
- Structures – The SFMP used structure information available in the HAZUS database, which is based on 2000 census information with economic values in 2006 dollars (FEMA, 2011). That information was then updated to 2010 dollars. Because HAZUS uses census information, structures are uniformly distributed within the census blocks, which does not necessarily represent the exact location of structures. The CVFPP developed a detailed structure inventory based upon 2010 parcel data, and the SFMP used that inventory within the CVFPP boundary.
- Critical facilities – The SFMP used facilities data available in HAZUS (FEMA, 2011). The CVFPP used these data as well. The following types of facilities are included:
    - Essential Facilities: Care facilities, emergency centers, fire stations, police stations, and schools
    - High Potential Loss Facilities: Dams and hazardous material sites
    - Lifeline Facilities: Wastewater facilities, potable water facilities, oil facilities, natural gas facilities, electric power facilities, and communications facilities
    - Transportation Facilities: Airport facilities, runways, rail facilities, railway bridges, railway segments, light-rail facilities, light-rail segments, port facilities, ferry facilities, bus facilities, highway bridges, and highway segments
- DoD facilities – The SFMP used an Environmental Systems Research Institute (ESRI) GIS (ESRI, 2008). Figure F-3 is a map showing locations of DoD facilities used in the analysis.
- Crops – The SFMP and the CVFPP used available county land use data that DWR compiled throughout the state. Where data were not available outside the CVFPP impact areas, the SFMP used crop acreage data from the HAZUS database (DWR, 2011). Both the SFMP and the CVFPP assigned yield and price data using county agricultural commissioner data, updated to 2010 dollars.
- California Natural Diversity Database (CNDDB) – Created by the California Department of Fish and Wildlife, Biogeographic Data Branch, dated April 4, 2009 (CDFW, 2009).
- Native American tribal lands –ESRI GIS database (ESRI, 2010). The map in Figure F-3 also shows locations of Native American tribal lands used in the analysis. This database includes Tribal lands currently held in trust by the United States government, but does not include those known as Public Domain Allotments.

Table F-2 summarizes the types and sources of data.

Table F-2. Types and Sources of Data Used for the SFMP Flood Hazard Exposure Analysis

Type of Data	Data Description	Data Sources	
		Outside CVFPP Boundary	Within CVFPP Boundary
Floodplains	Describes extent of flood hazard for the 100- and 500-year events.	FEMA FIRMs or most recent maps provided by the USACE	CVFPP floodplains as of October 4, 2011
Population	Describes the total population exposed to flooding.	HAZUS California database: • Demographics	HAZUS California database: • Demographics
Structures	Describes the total number and depreciated replacement values of structures exposed to flooding (residential, commercial, industrial, and public).	HAZUS California database: • Demographics	CVFPP structure inventory based upon ParcelQuest county assessor data
Critical Facilities and DoD Facilities	Describes the number of essential, high potential loss, transportation, utility, and DoD facilities exposed to flooding.	HAZUS California databases: • Essential facilities • High potential loss • Transportation • Utilities DoD facilities (GIS database [ESRI, 2008])	HAZUS California databases: • Essential facilities • High potential loss • Transportation • Utilities DoD facilities (GIS database [ESRI, 2008])
Crops	Describes the number and value of crop acres exposed to flooding (deciduous, citrus, field, truck, and vineyard).	California DWR county land use surveys (DWR, 2012) HAZUS California database: • Agriculture County agricultural commissioner yield and price data	California DWR county land use surveys (DWR, 2012) County agricultural commissioner yield and price data
California Natural Diversity Database	Describes the number of sensitive plant and sensitive animal species exposed to flooding	California Department of Fish and Wildlife, Biogeographic Data Branch (April 4, 2009)	California Department of Fish and Wildlife, Biogeographic Data Branch (April 4, 2009)
Native American Tribal Lands	Describes the number and acreage of Tribal land areas exposed to flooding	GIS database (ESRI, 2010)	GIS database (ESRI, 2010)

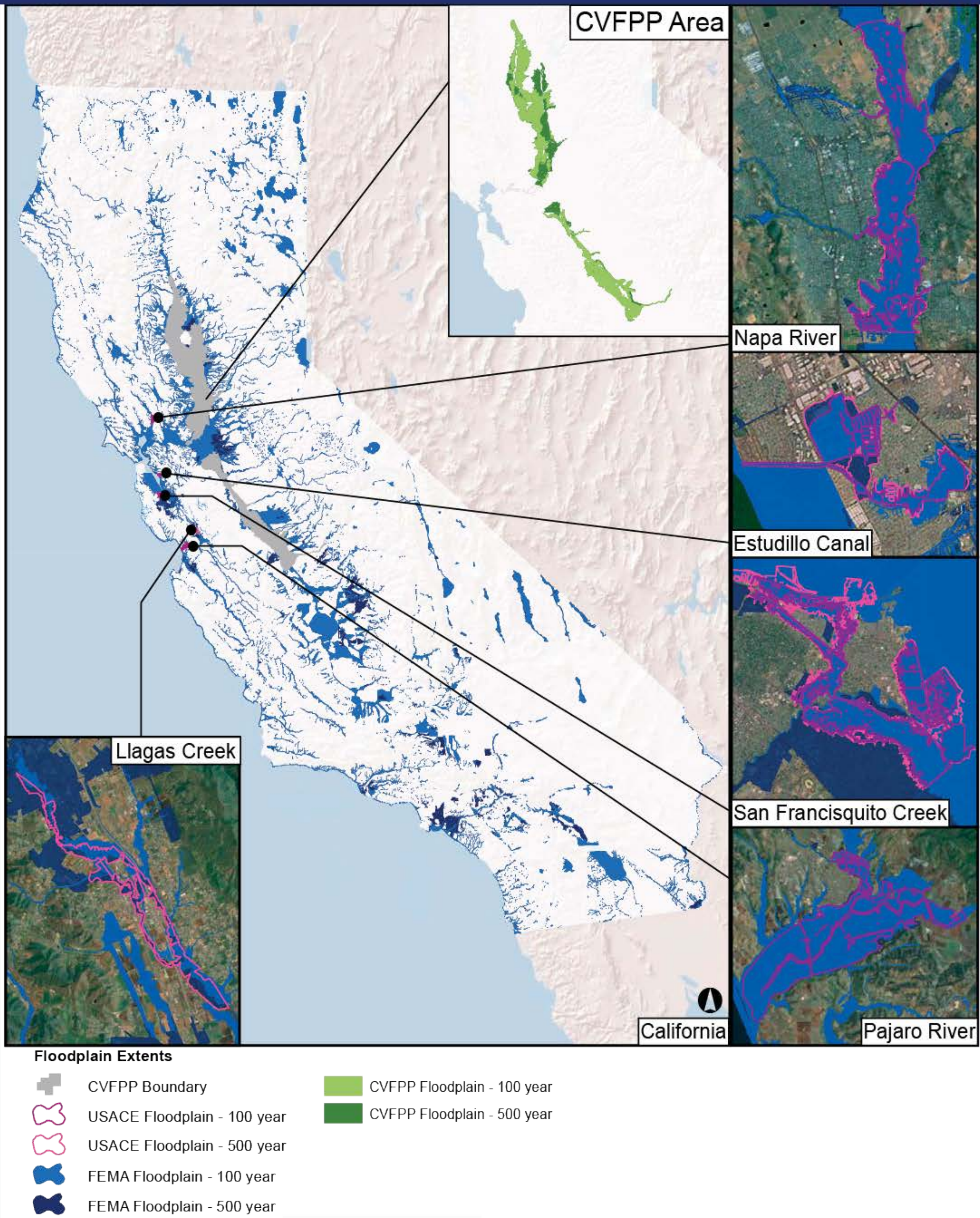

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Figure F-2
Floodplains Used for Flood Hazard Exposure Analysis

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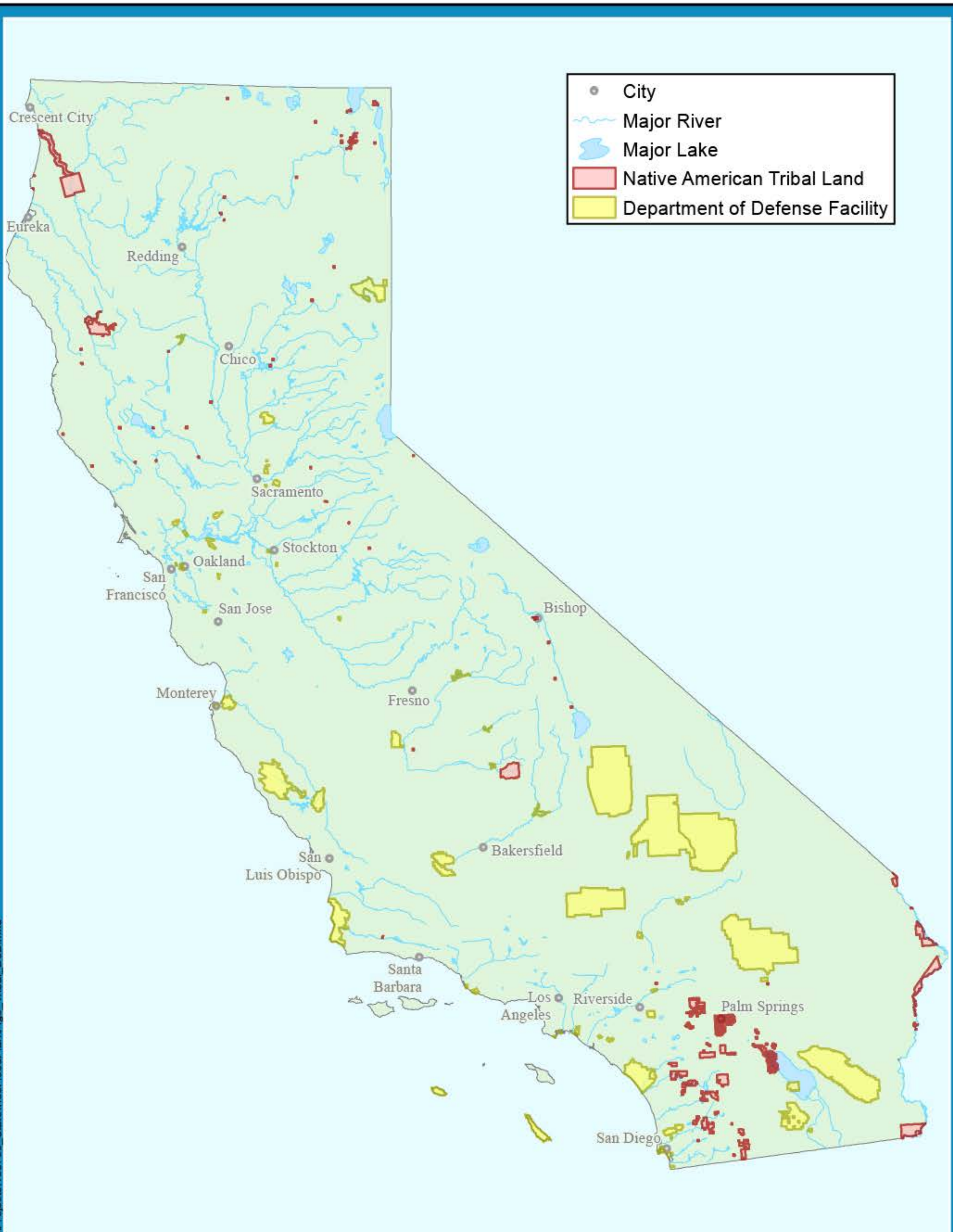

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Figure F-3: Department of Defense Facilities and Native American Tribal Lands Used in the Analysis

Source: National Atlas of the United States and the United States Geological Survey, ESRI (published 4/1/2008 and 6/30/2010). Note that the Tribal lands used in the analysis include those currently held in Trust by the United States Government but not those known as Public Domain Allotments

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3.2 Analysis Regions

This section describes the types of regions used in the flood hazard exposure analysis and provides an explanation of why each type was selected. The types of regions used for analysis include:

- CWP Hydrologic Regions: There are 10 CWP hydrologic regions and 2 overlay regions, which are shown in Figure F-4. Use of these analysis regions allows for consistency with other DWR programs and for integration into the CWP Update 2013. Each of the CWP hydrologic regions and overlay regions is described in Section 4.2 of this Attachment F.
- Counties: There are 58 counties in California, which are shown in Figure F-5, and all of them were contacted during the SFMP effort. Use of counties as analysis regions allows county officials and local agencies to easily view the results of this analysis. In addition, counties are identifiable geographic units, which facilitates dissemination of the analysis results to multiple audiences (for example, flood management agencies and the public).
- State Senate and Assembly Districts: As currently drawn (fall 2011), there are 80 assembly districts and 40 senate districts in California, which are shown in Figures F-6 and F-7, respectively. Use of these districts as analysis regions allows State assembly and senate representatives to relate the analysis results directly to their constituents by presenting results at the district level.
- U.S. Congressional Districts: As currently drawn (fall 2011), California has 53 congressional districts, which are shown in Figure F-8. Use of these districts as analysis regions allows members of the U.S. House of Representatives to relate the analysis results directly to their constituents by presenting results at the district level.
- Delta Zones (primary and secondary): California Public Resources Code section 29700 *et seq*., the Johnston-Baker-Andal-Boatwright Delta Protection Act of 1992, included mandates for the designation of primary and secondary zones within the legal Delta. The Delta region has statewide significance, and areas within the primary and secondary Delta zones are subject to specific regulations. Use of these zones as analysis regions allows interested parties to focus on the analysis results in the Delta. The primary and secondary Delta zones are shown in Figure F-9.
- Integrated Regional Water Management regions: As of September 1, 2011, there are 48 IRWM regions in California, which are shown in Figure F-10. Because an IRWM region is a collaboration of local agencies, some IRWM regions overlap, and some parts of the state are not covered by an IRWM region. In addition, the number of regions changes as applicants are accepted into the IRWM program. IRWM regions cross jurisdictional, watershed, and political boundaries and can involve multiple agencies and stakeholders. Use of these regions in the analysis allows IRWM groups to focus on the analysis results within their region, which allows consistency with the IRWM grant programs administered by DWR. In addition, DWR is moving toward an IWM approach, which includes IRWM planning.

Figure F-4: CWP Hydrologic Regions and Overlay Regions Used in the Analysis

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Figure F-5: Counties Used in the Analysis

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Figure F-6: State Assembly Districts Used in the Analysis

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Figure F-7: State Senate Districts Used in the Analysis

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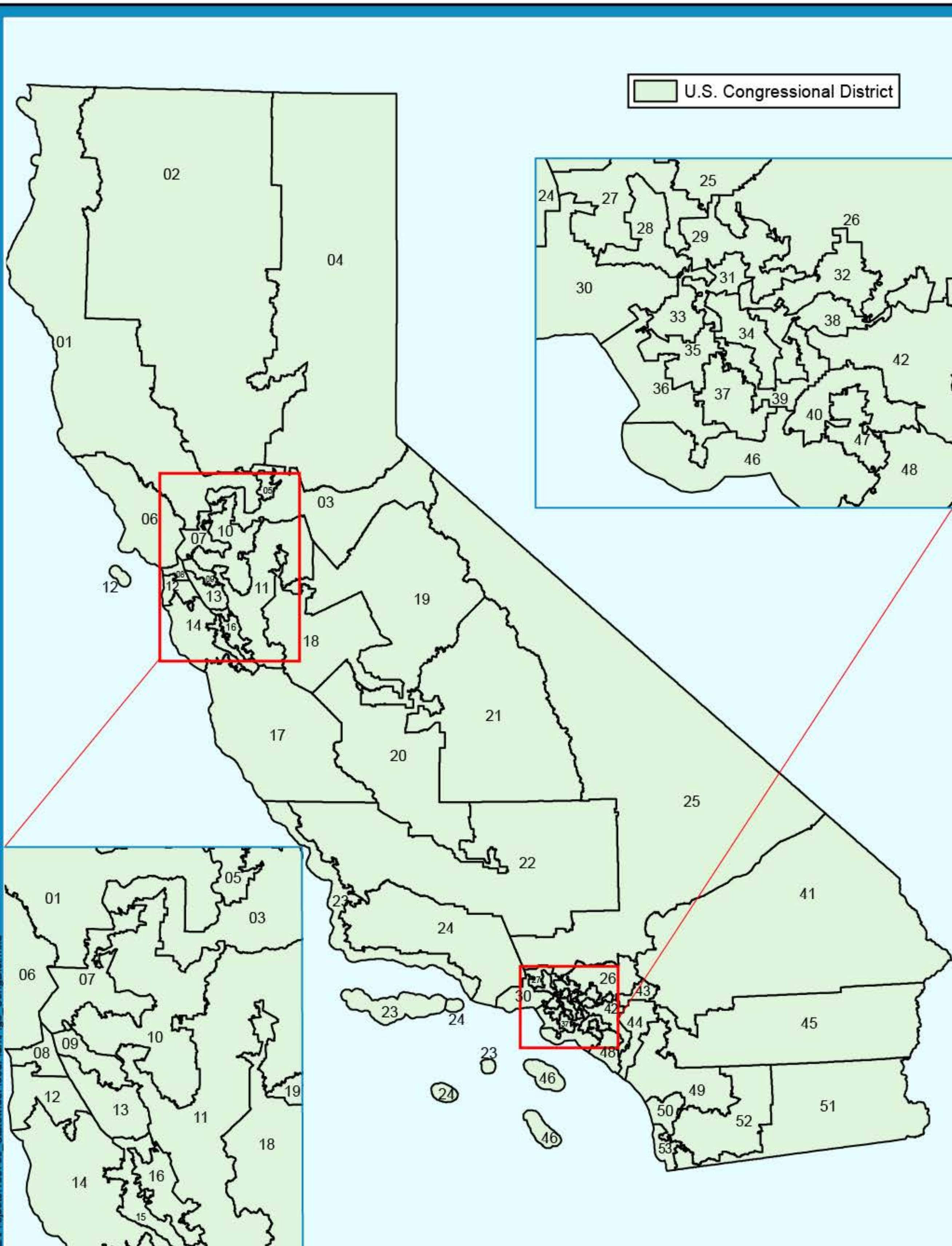

Figure F-8: U.S. Congressional Districts Used in the Analysis

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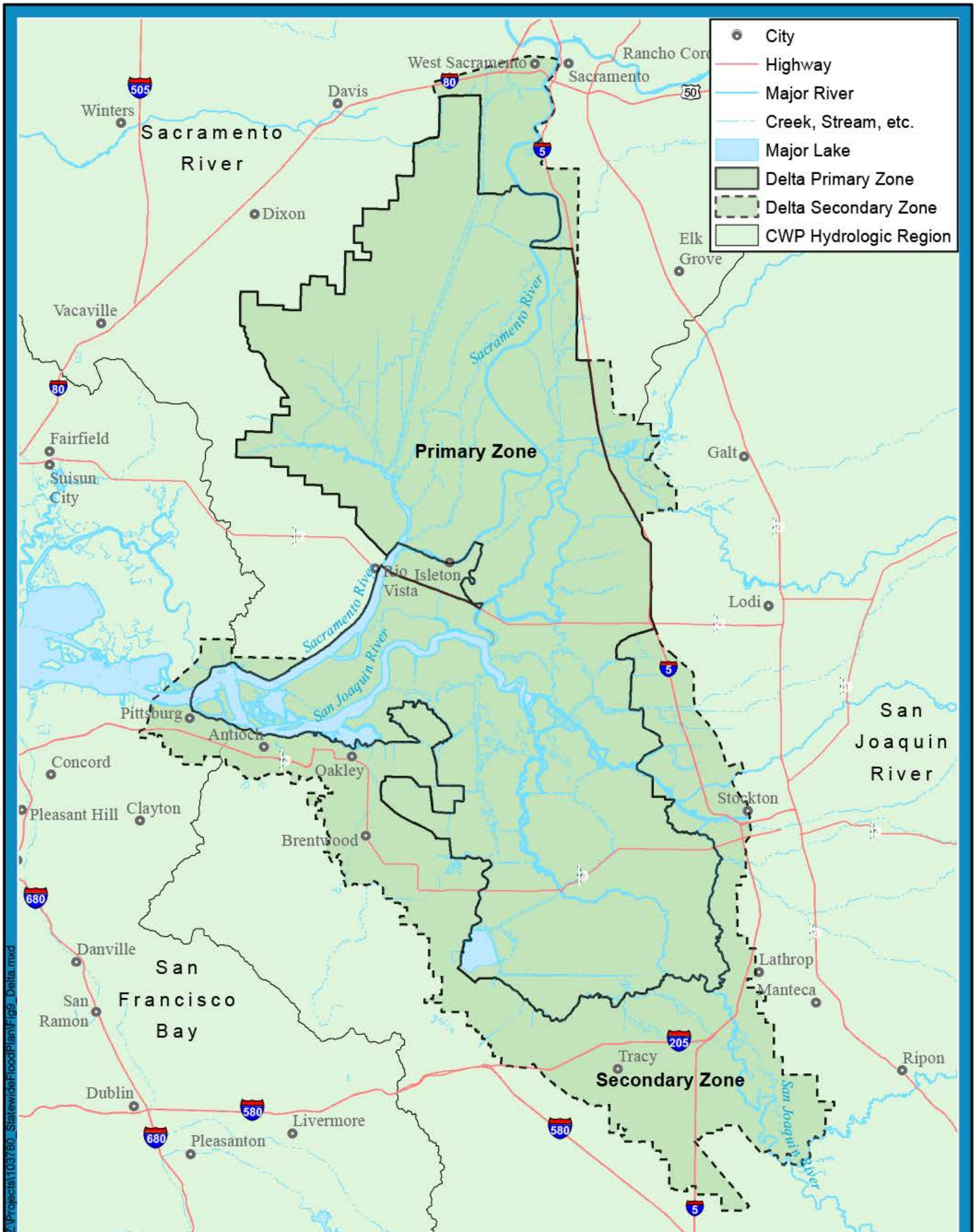

Figure F-9: Primary and Secondary Delta Zones Used in the Analysis

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

November 9, 2012

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Figure F-10: Integrated Regional Water Management Regions Used in the Analysis

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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3.3 Procedures Used for Analysis

The flood hazard exposure analysis was performed by using ArcGIS to intersect floodplains in the various analysis regions described above with spatial data from HAZUS and other databases. These intersections are used to determine population, number of structures, crop acreage and type, numbers and types of critical facilities, number and acreage of DoD facilities, and number and acreage of Native American tribal lands exposed to flooding. The procedures used to analyze each region are summarized below.

3.3.1 Population

To estimate the exposed population within each analysis region, the following steps were completed:

1. Calculated each census block area (in acres) and the total population within each census block.
2. Clipped the census block shapefile with the analysis region boundary shapefile (e.g., counties, hydrologic regions) to remove those census blocks that were outside the analysis region.
3. Overlaid the floodplain shapefile onto the clipped census block shapefile for the analysis region.
4. Calculated the area of each census block within the analysis region that was exposed to the floodplain.
5. Calculated the exposed percentage of each census block (divided the area that is exposed by the total area of the census block).
6. Used the percentage from Step 5 to calculate the population exposed in each census block in the analysis region.
7. Summed the exposed populations for all census blocks within the analysis region to compute the total exposed population for the analysis region.

3.3.2 Structures

To estimate the numbers and values of exposed structures within each analysis region outside the CVFPP boundary, the following steps were completed:

1. Calculated each census block area (in acres).
2. Calculated the total number of structures, their total full replacement value, and the total full replacement value of the contents of those structures within each census block.
3. Clipped the census block shapefile with the analysis region boundary shapefile to remove those census blocks that were outside the analysis region.
4. Overlaid the floodplain shapefile onto the clipped census block shapefile for the analysis region.
5. Calculated the area of each census block within the analysis region that was exposed to the floodplain.
6. Calculated the exposed percentage of each census block (divided the area that is exposed by the total area of the census block).

7. Used the percentage from Step 6 to calculate the number of structures, replacement value of the structures, and replacement value of the contents of the structures in each census block that was exposed to the floodplain.

The full replacement values of structures and contents were adjusted for depreciation, location costs, and updated price levels. Depreciated replacement values were used to be consistent with USACE risk analyses and the CVFPP risk analysis. To convert the full replacement values to depreciated replacement values, the following steps were completed:

1. Determined the median year of all structures within each census block.
2. Subtracted the median year from 2010 to determine the age of all structures in each census block.
3. Determined the appropriate average depreciation percentage factors from Table F-3. If the HAZUS database had "0" as a Median Year Built for any of the structures, the weighted average of the structures within the adjacent census blocks for Median Year Built was used.
4. Multiplied the full replacement value times (1 minus depreciation percentage factor).

The depreciated replacement values were then adjusted to reflect localized construction costs for the analysis region. To localize these values, the following steps were completed:

1. Identified the appropriate county location cost factors in Table F-4.
2. Multiplied the county location cost factor by the total depreciated values of structures and contents.

The localized construction costs were also updated to 2010 dollars from 2006 dollars. To do this, localized values of all exposed structures and contents were multiplied by the *Engineering News Record* Building Cost Index update factor of +1.12.

Finally, the number of structures and the depreciated values of structures and contents were summed for all the census blocks within the analysis region to compute the total values for the analysis region.

Within the CVFPP boundary, structure inventory shapefiles (based upon county assessor's ParcelQuest data) were used to characterize flood hazard exposure. The structure inventory point shapefiles included depreciated values in 2010 dollars for the replacement structures and contents, which simplified the procedure. To estimate the exposed structures within the CVFPP boundary, the following steps were completed:

1. Overlaid the CVFPP floodplain shapefile onto the CVFPP structure inventory point shapefile.
2. Counted the number of structures that were exposed to the CVFPP floodplain.
3. Summed the depreciated replacement values of structures exposed to the CVFPP floodplain.
4. Summed the depreciated replacement values of contents exposed to the CVFPP floodplain.

Table F-3. HAZUS Depreciation Factors Averaged for all Types of Structures

Building Age (1)	Average Depreciation Factor (%) (2)	Building Age (3)	Average Depreciation Factor (%) (4)	Building Age (5)	Average Depreciation Factor (%) (6)
1	0.47	34	38.47	67	74.59
2	1.58	35	39.59	68	75.65
3	2.70	36	40.71	69	76.71
4	3.82	37	41.83	70	77.77
5	4.94	38	42.95	71	78.83
6	6.06	39	44.06	72	79.89
7	7.17	40	45.18	73	80.95
8	8.29	41	46.30	74	82.01
9	9.41	42	47.42	75	83.08
10	10.53	43	48.53	76	84.14
11	11.65	44	49.65	77	85.20
12	12.76	45	50.77	78	86.26
13	13.88	46	51.89	79	87.32
14	15.00	47	53.01	80	88.38
15	16.12	48	54.12	81	89.44
16	17.23	49	55.24	82	90.50
17	18.35	50	56.36	83	91.56
18	19.47	51	57.48	84	92.62
19	20.59	52	58.60	85	93.69
20	21.71	53	59.69	86	94.75
21	22.82	54	60.79	87	95.81
22	23.94	55	61.85	88	96.87
23	25.06	56	62.92	89	97.93
24	26.18	57	63.98	90	98.99
25	27.30	58	65.04	91	99.10
26	28.41	59	66.10	92	99.21
27	29.53	60	67.16	93	99.30
28	30.65	61	68.22	94	99.39
29	31.77	62	69.28	95	99.48
30	32.88	63	70.34	96	99.57
31	34.00	64	71.40	97	99.66
32	35.12	65	72.47	98	99.75
33	36.24	66	73.53	99	99.84
				100+	99.93

Source: FEMA, 2011

Table F-4. HAZUS County Location Cost Adjustment Factors

County	Location Cost Factor	County	Location Cost Factor
Alameda	1.15	Placer	1.08
Alpine	1.08	Plumas	1.09
Amador	1.09	Riverside	1.03
Butte	1.09	Sacramento	1.10
Calaveras	1.09	San Benito	1.09
Colusa	1.11	San Bernardino	0.99
Contra Costa	1.14	San Diego	1.04
Del Norte	1.06	San Francisco	1.22
El Dorado	1.10	San Joaquin	1.10
Fresno	1.08	San Luis Obispo	1.07
Glenn	1.11	San Mateo	1.19
Humboldt	1.07	Santa Barbara	1.06
Imperial	0.94	Santa Clara	1.14
Inyo	1.03	Santa Cruz	1.18
Kern	1.05	Shasta	1.09
Kings	1.07	Sierra	1.07
Lake	1.12	Siskiyou	1.06
Lassen	1.05	Solano	1.12
Los Angeles	1.05	Sonoma	1.15
Madera	1.07	Stanislaus	1.12
Mariposa	1.08	Sutter	1.10
Mendocino	1.10	Tehama	1.10
Merced	1.08	Trinity	1.08
Modoc	1.05	Tulare	1.05
Mono	1.04	Tuolumne	1.07
Monterey	1.09	Ventura	1.06
Napa	1.12	Yolo	1.11
Nevada	1.06	Yuba	1.10
Orange	1.05	Marin	1.19

Source: FEMA, 2011

3.3.3 Agriculture

To determine the exposed agricultural acreage and gross crop market values, the following steps were completed:

1. Clipped the DWR combined county land use survey shapefile (if available) or the HAZUS agricultural database with the analysis region boundary shapefile to remove areas outside the analysis region.
2. Overlaid the floodplain shapefile onto the clipped land use shapefile for the analysis region.
3. Determined the exposed agricultural acreage located within the floodplain.
4. Determined the value of exposed agricultural acreage using county agricultural commissioner's crop yield and price per unit data:
   a. To estimate total exposed crop yields, the yield information obtained from the county agricultural commissioner's data (units per acre) was multiplied by the number of exposed acres, for each exposed crop.
   b. To estimate total exposed crop values, the price information obtained from the county agricultural commissioner's data ($/unit) was multiplied by the estimated exposed yield.
5. Where there were "missing" crop data, the following guidelines were used:
   a. For crops that are identified under DWR land use data and are not listed in the agricultural commissioner's data, yield and price data from similar crops within the agricultural commissioners' data were used. If similar crops could not be determined, then certain crops were classified as "excluded crop"; the area was reported in the results table, but values were not reported. Certain crops were also classified as "non-crop" (for example, native vegetation); these areas and values are not reported. Where HAZUS land use information was used, the HAZUS crop types were matched to similar crops within the agricultural commissioner's data. As described below, county data were preferred, but if the data were not available, then state total data were used.
   b. When a county's agricultural commissioner's yield and price data were missing for a given crop, state totals were used for that crop. For example, almonds are identified in Napa County using DWR's land use data, but the county agricultural commissioner's data did not provide price or yield data for almonds. Therefore, the state total almond yield (0.96 tons per acre) and price ($3,189.21 per ton) were used for Napa County.
6. Reported total exposed agricultural acreage. DWR crop data are organized by major crop categories. These categories are defined in the standard DWR Land Use Legend (DWR, 2005):
   - Grain and hay
   - Rice
   - Field
   - Pasture
   - Truck, nursery, and berry crops

- Deciduous fruits and nuts
- Citrus and subtropical
- Vineyards

7. Reported exposed acreage for the subset of crops for which economic value was computed.
8. Reported value of exposed crops.
9. To update crop values to 2010 price levels, the crop price index factors provided in Table F-5 were used. These factors were applied to the total crop category values rather than the specific crops within the crop categories.

Table F-5. USDA 2010 Crop Price Index Factors for Major Crop Categories

Major Crop Category	Price Index Factor
Grain and hay	1.31
Rice	1.02
Field	1.28
Pasture	1.02
Truck, nursery and berry crops	0.87
Deciduous fruits and nuts	1.07
Citrus and subtropical	1.02
Vineyards	1.07

Source: USDA, 2010

3.3.4 CNDDB Species

To determine the number of sensitive plant species and sensitive animal species exposed, the following steps were completed:

1. Clipped the CNDDB shapefile with the analysis region boundary shapefile to remove those CNDDB areas located completely outside the analysis region.
2. Overlaid the floodplain shapefile onto the clipped CNDDB shapefile.
3. Counted the number of sensitive plant species and sensitive animal species located partly or entirely within the floodplain and determined their acreage.

3.3.5 Critical Facilities and Department of Defense Facilities

To determine the number of exposed critical facilities for all categories other than DoD facilities, the following steps were completed:

1. Clipped the appropriate HAZUS facility point shapefiles with the analysis region boundary shapefile to remove those facilities that were located completely outside the analysis region.
2. Overlaid the floodplain shapefile onto the clipped facility shapefile for the analysis region.
3. Counted the number of critical facilities located partly or entirely within the floodplain.

To determine the number (not acreage) of exposed DoD facilities, the following steps were completed:

1. Clipped the DoD facility polygon shapefile with the analysis region boundary shapefile to remove those DoD facilities that were located completely outside the analysis region.
2. Overlaid the floodplain shapefile onto the clipped DoD facilities shapefile.
3. Counted the number of DoD facilities located partly or entirely within the floodplain and determined their acreage.

3.3.6 Native American Tribal Lands

To determine the number and acreage of exposed Native American tribal lands, the following steps were completed:

1. Clipped the Tribal land areas polygon shapefile with the analysis region boundary shapefile to remove those Tribal land areas located completely outside the analysis region.
2. Overlaid the floodplain shapefile onto the clipped Tribal land areas shapefile.
3. Counted the number of Tribal lands located partly or entirely within the floodplain and determined their acreage.

3.4 Analysis Steps

3.4.1 Method Testing

Two test cases were analyzed by four consulting teams as part of the development and refinement of the flood hazard exposure analysis method. The first test case was for Napa County. The proposed procedures were used to estimate the exposed areas, population, and numbers and values of structures and crops. The lessons learned from this test case helped in the initial formulation of the analysis method.

Next, a second test case, this time for Marin County, was analyzed to help refine the details of the method. Each consulting team computed independently the following values for Marin County:

- Exposed population
- Exposed area
- Number of exposed structures
- Depreciated replacement value of exposed structures
- Exposed agricultural acreage
- Market value of exposed crops

The consultant teams compared their results to ensure that the method was clear and that each team was properly following the method. Discrepancies in the results computed by the different teams revealed some areas where refinements were needed to ensure consistency in the analysis. Once these refinements were made, the values computed by each team were equal, demonstrating that the analysis method could be applied independently to achieve the same results.

3.4.2 Estimates of Exposure to Flood Hazard

The flood hazard exposure analysis involved analysis teams from four different consulting firms. Because of differences in data for the CVFPP and the rest of the state, computations for within the CVFPP boundary and those for the rest of the state were assigned to different analysis teams. Each team completed the analysis steps described above for its assigned analysis regions. In cases where the boundary of the CVFPP cut across an analysis region boundary, computations were performed separately for the CVFPP and non-CVFPP portions of the analysis region. The resulting values were then added together to obtain estimates of total exposure for the entire analysis region.

3.4.3 Quality Assurance/Quality Control

After each team completed the analysis steps, a quality assurance/quality control (QA/QC) process was completed. Study teams exchanged their draft work products and followed a consistent QA/QC process. All QA/QC steps were completed for all analysis regions for both the 100-year and 500-year floodplains. The QA/QC process answered the following questions:

- Were the area, total population, number of structures, total full replacement value of structures, and total full replacement value of contents recorded, and do values seem reasonable?
- Were the exposed area, exposed population, full replacement value of exposed structures, and full replacement value of exposed contents recorded, and do values seem reasonable?
- Were replacement values of structures and contents depreciated based on median structure age and the average depreciation factor?
- Were replacement values of structures and contents localized using the appropriate county location cost factors?
- Were the depreciated structure and content values updated to 2010 dollars using the *Engineering News Record* Building Cost Index update factor of +1.12?
- Were exposed essential facilities, including high potential loss facilities, lifeline utilities, transportation facilities, and military facilities, estimated correctly?
- Were the DWR county land use survey data used as the primary source for estimating exposed crops?
- Was the HAZUS crop database used as a secondary source for estimating exposed crops?
- Were the DWR and HAZUS crop data merged correctly?
- Were the correct crop categories included in exposed crop calculations?
- Were exposed crops used for valuation computed correctly?

- Were crop values determined using county agricultural commissioners' yield and price data?
- Were crop values updated to 2010 levels using the U.S. Department of Agriculture (USDA) price indices for the crop categories?

Inconsistencies in draft work products were noted and discussed with each study team until the results were verified and multiple teams working independently produced the same results.

3.5 Limitations of Analysis

3.5.1 Direct Limitations of Analysis Method

Analysis of exposure to flood hazard is appropriate for identifying areas of California at risk of flooding and for formulating conceptual plans or identifying broad categories of solutions to flood problems. However, the flood hazard exposure analysis method and results have certain limitations and should be interpreted with care. Limitations and cautions include the following:

- This study did not compute risk, such as expected annual consequence (damage or loss of life, for example), as would be done with a detailed risk analysis. Nor did this study compute actual damage for the 100-year and 500-year events. Rather, this study tabulated the number of people and the number and value of various assets within the footprints of the 100-year and 500-year events. Thus, these estimates should not be interpreted as information for use in a benefit-cost analysis or as the test for making investment decisions. The estimates can, however, support identification, comparison, and prioritization of broad categories of flood management solutions.
- Hazard information, particularly floodplain delineations, used herein is based on the best information available to analysts when calculations were completed in September and October 2011. This information included FEMA floodplain maps, floodplain maps provided by USACE, and floodplain maps provided by DWR that were developed as a component of the CVFPP. This hazard information provides a reasonable estimate of the extent of flooding, but it is not (and this study is not) intended to provide a firm line that divides flooded areas from dry areas.
- In areas outside the CVFPP boundary, this study did not include detailed geotechnical engineering analyses to confirm or refine forecasts of levee performance. If levees were accredited by FEMA, they were included here. Note that within the CVFPP boundary, levee fragility functions informed delineation of the inundation area.
- This study covers areas that are in FEMA-, CVFPP-, or USACE-delineated floodplains. About 0.5 percent of the state (including all of Alpine County and most of San Francisco County) did not have floodplain delineation available and therefore was not covered by the study.

- Population estimates used for this study are from the 2000 U.S. Census. This is consistent with population estimates used in the CVFPP life-safety analysis. The effect on the results of using 2000 census data instead of 2010 census data is unknown; however, the 2010 census reported an increase in statewide population from 34 million to 37 million.
- Structure values within the CVFPP boundary are derived from the exposure data used for the CVFPP. Outside the CVFPP boundary, values from FEMA's HAZUS database were used; this study did not refine those structure estimates.
- Because HAZUS uses census information, structures are uniformly distributed within the census blocks, which would not represent the exact location of structures. Thus, outside the CVFPP boundary (which used geospatial parcel data), the study may not be accurately tabulating exact counts of structures within the flood event footprints. However, these tabulations are acceptable for a statewide exposure analysis. The estimates of crop acreage and values exposed to flooding were derived from several sources, including local, State, and Federal agencies. DWR and HAZUS crop types were matched with the appropriate county agricultural commissioner's yield and price data for the entire state. Although the team made its best attempt to ensure accuracy in matching these data, some discrepancies could be present, which would affect the crop value estimates. When the match between DWR/HAZUS crop types with the county agricultural commissioner's data could not be made, only exposed acreage was reported.
- The results in this study present only the number of sensitive plant species and sensitive animal species exposed, which is the intent of the report.
- Due to the analytical methods and available data, the results of the study do not cover the beneficial aspects of natural floodplain functions and implementing an IWM approach to floodwater management. A more integrated approach enhances the ability of undeveloped floodplains and other open spaces to behave more naturally and absorb, store, and slowly release floodwaters during small and medium-sized events. Flood Management, as part of an IWM approach, considers land and water resources on a watershed scale, employing both structural and nonstructural measures to maximize the benefits of floodplains and minimize loss of life and damage to property from flooding, and recognizing the benefits to ecosystems from periodic flooding. An IWM approach recognizes that periodic flooding of undeveloped lands adjacent to rivers and streams is a natural function and can be a preferred alternative to restricting flood flows to an existing channel. The intent of natural floodplain function restoration is to preserve or restore the natural ability of undeveloped floodplains to absorb, hold, and slowly release floodwaters, to enhance the ecosystem, and to protect flora and fauna communities. Natural floodplain function conservation and restoration actions can include both structural and nonstructural measures. To permit seasonal inundation of undeveloped

floodplains, some structural improvements (e.g., weirs) might be needed to constrain flooding within a defined area along with nonstructural measures to limit development and permitted uses within those areas subject to periodic inundation.

3.5.2 Loss of Function

This attachment quantifies the exposure to flood hazard of population, structures, important facilities, and crops using a consistent methodology statewide. While this approach represents an important first step in statewide flood management planning, other factors that are not easily quantifiable should be considered in a more detailed study. For example, a more detailed study would evaluate not only the direct physical damages to inundated structures and crop losses typically included in a flood risk assessment but also the loss of function to those inundated structures (residential, commercial, industrial, public, and others) and infrastructure (such as transportation, health and human services, water supply, wastewater treatment, utilities, energy generation, and emergency services). In addition, floods will affect ecosystems and regional economic activity. Loss-of-function impacts are briefly described below.

Impacts from flooding to transportation systems can be substantial. The interruption to the movement of people, goods, and services could last from days to months following a large flood event. Urban communities could experience delays in commuting, having to find alternative routes, and rural communities could have their sole transportation corridor cut off because of the flooding, isolating the community. Critical facilities, such as hospitals, nursing homes, police and fire stations, and other government buildings, may also be isolated by the flood, requiring additional resources to maintain their operations. Evacuations to other facilities and buildings outside the flooded area could be required. Although the delays and the additional expenses incurred caused by using longer alternative routes are not significant to the overall flood mitigation and recovery costs, they still can be substantial in terms of absolute dollar amounts—on the order of hundreds of thousands to a few million dollars. For example, it is estimated that a 1-day closure of Highway 101 in South San Francisco Bay (which averages approximately 400,000 trips per day) would cost several million dollars.

Health and human services may be affected during floods, with the limited availability of potable water to the community frequently being a primary concern. Temporary closures of medical clinics, schools, welfare services, and other governmental services could affect a much larger portion of the community than those areas directly flooded. A flood could overload wastewater treatment facilities, causing a release of untreated sewage into rivers, bays, or the ocean, or possibly backing up the sewer system to the street level. Untreated sewage would increase the number of disease-carrying insects and other pathogens in the area. Water supplies could be limited by the flooding, due to temporary closures of pumping facilities or contamination of water sources. A statewide worst-case scenario would be the flooding of the State's water system (including the State Water Project and Central Valley Project), which potentially would affect 25 million urban water users and 3 million acres of irrigated farmland. Approximately one-quarter of the State's population depends fully on the State's water system for drinking water, and two-thirds of the State partially depends on the system for drinking water.

Besides water supply, the flow of gas and electrical transmission could be affected by flooding. Disruption of utilities during and following a flood could hamper emergency responses and post-flood economic activities, delaying the return to normalcy for residents of the flooded area. Additionally, if energy generation facilities are within the flooded area, they might have to shut down, decreasing the energy available on the grid.

During the response to a flood, emergency services are critical, such as closing off affected areas, routing people away from the flood, protecting against looting and vandalism, providing emergency medical care, evacuating trapped residents, flood fighting, and other services. Emergency services should be minimally affected for communities that have sufficient space and have properly planned for flood events. During major floods, the emergency response capabilities and/or infrastructure of a community can be overwhelmed; outside assistance requires the allocation of resources from areas not affected by the flood.

Ecosystem functions could also be adversely affected, depending upon the magnitude and duration of the flood event. Habitats other than riparian (upland, for example) may be impacted by flooding, resulting in temporary displacement, or permanent destruction of affected flora and fauna habitats, including habitat for endangered species. The flooding effects on flora will depend on the vulnerability of the species to inundation and the duration of the flood, and the flooding effects on fauna will depend on the ability of the species to move out of the area or find refuge before inundation occurs. Flooding is a natural process for riparian ecosystems, and the effects of flooding can be beneficial to native species with the creation of new habitat, to soil fertility with the importation of nutrients, and to groundwater quality and rate of recharge. However, in the case of catastrophic flooding, or flooding resulting from structural failures (such as dams and levees), even riparian ecosystem functioning can be adversely affected over both short and long terms, and perhaps permanently.

Recreation is also affected by floods, with temporary closures of trails and parks, or destruction of some recreational features during the flood. Examples of recreational projects statewide that would be affected by floods include the Santa Ana River Trail, which (when completed) will run 110 miles along the river from Big Bear Lake to the Pacific Ocean; Discovery Park, a 160-acre park located at the confluence of the American and Sacramento rivers in downtown Sacramento; and the San Francisco Bay Trail, a 500-mile shoreline trail along the San Francisco Bay. Although these examples represent smart land-use planning decisions regarding flood hazards, they still would require time and resources to reopen following a major flood event, thereby limiting recreational opportunities.

Finally, in addition to the physical damage and loss of functions within a flooded region, economic activity can be affected beyond that region. For example, flooded businesses may experience disruptions in the flow of goods and services in and out of the region. This could result in direct and indirect income and employment losses in those other regions. The disruption of infrastructure within a flooded region could also have effects outside the region. For example, flooded water or power supply infrastructure that supplies other regions might cause direct and indirect losses within those regions due to supply interruptions. Alternatively, businesses that support recovery efforts and are located outside the flooded area might experience a boom. Federal and State governments can provide financial assistance that offsets losses within the flooded region, but these expenditures have implications for their budgets (and ultimately the taxpayers) outside the region.

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4.0 Results of SFMP Flood Hazard Exposure Analysis

4.1 Statewide Results

This section provides an overview of the statewide results of the flood hazard exposure analysis. The analysis estimated population, depreciated replacement value of structures and content, market value of crops, numbers of critical facilities, and numbers and acreage of Native American tribal lands and DoD facilities that are within the 100-year and 500-year floodplains as determined by the CVFPP (in the Central Valley) or by FEMA or the USACE (outside the Central Valley) for each analysis region. Because this study did not compute risk (e.g., the likelihood of loss of life or actual damage for the 100-year and 500-year events), these estimates should not be interpreted as information for use in a benefit-cost analysis or as the test for making investment decisions. The estimates can, however, support identification, comparison, and prioritization of broad categories of flood management solutions.

The statewide exposure to flood hazard from the 100-year floodplain totals about 1.4 million people, $136 billion in value of structures and their contents, and $5.4 billion in crop values. The statewide exposure to flood hazard from the 500-year floodplain totals about 7.3 million people, $577 billion in value of structures and their contents, and $7.5 billion in crop values. Thus, the exposure to the 500-year floodplain is about 420 percent more than the exposure to the 100-year floodplain in terms of people exposed, with increases of about 320 percent in structures and contents value and about 40 percent in crop value compared to the 100-year floodplain.

To help understand how the exposure to flood hazard is distributed across the state, results are presented for the following categories:

- Counties
- State Assembly, State Senate, and U.S. Congressional Districts
- IRWM Regions
- Delta Zones
- Mountain Counties
- CWP Hydrologic Regions

Detailed results for each analysis region are provided in Appendices B through H. For each category, two figures are presented, representing 100-year and 500-year floodplains. Each figure delineates the relative exposure of population, structure and contents value, and crop values.

Statewide Results

100-Year Floodplain (1% annual chance of flooding)

- 1.4 million people
- $136 billion in structures and contents values
- $5.4 billion in crop values

500-Year Floodplain (0.2% annual chance of flooding)

- 7.3 million people
- $577 billion in structures and contents values
- $7.5 billion in crop values

4.1.1 Counties

Tables F-6, F-7, and F-8 and Figures F-11 and F-12 show the relative exposure results for the counties in terms of population, value of structures and contents, and value of agricultural crops in the 100-year and 500-year floodplains. In addition, Figures F-13 and F-14 show the percentage exposed in each county for each category.

County Results

Population and Value of Structures and Contents

Orange, Santa Clara, and San Mateo counties have the most exposure to the 100-year floodplain.

Orange, Santa Clara, and Los Angeles counties have the most exposure to the 500-year floodplain, with more than 45% of the statewide total.

Agricultural Crops Value

Exposure is concentrated in 12 counties that comprise more than 70% of the statewide total.

Urban exposure to flood hazard for the 100-year floodplain is widely distributed among California counties, with 29 counties having more than 10,000 people exposed and 28 counties having more than $1 billion in structures and contents exposed. Orange, Santa Clara, and San Mateo counties have the most exposure in terms of population and value of structures and their contents. These three counties each have more than 100,000 people and more than $10 billion in structures and contents exposed to the 100-year floodplain.

Urban exposure to the 500-year floodplain is more concentrated, with about 45 percent of the statewide exposure of population and value of structures and contents occurring in just three counties—Orange, Santa Clara, and Los Angeles. In total, 15 counties have a population of more than 100,000 and 14 counties have more than $10 billion in structures and their contents exposed to the 500-year floodplain. Four counties—Yuba, Yolo, Merced, and Colusa—have more than 25 percent of their populations exposed to the 100-year floodplain. Five counties—Sutter, Yuba, San Joaquin, Monterey, and Tulare—have more than 50 percent of their populations exposed to the 500-year floodplain.

Most of the agricultural exposure to the 100-year floodplain occurs in 12 counties (San Joaquin, Fresno, Kern, Kings, Merced, Yolo, Tulare, Monterey, Madera, Sutter, Ventura, and Butte), each of which has more than $100 million in exposed agricultural crops. These 12 counties contain more than 70 percent of the total value of exposed agricultural crops in the state. Five additional counties—Humboldt, Marin, Plumas, Yolo, and Del Norte—have more than 50 percent of their agricultural acreage exposed to the 100-year floodplain.

Agricultural exposure to the 500-year floodplain is concentrated in the same 12 counties plus 5 additional counties (Sacramento, Imperial, Solano, Yuba, and Riverside), where each county has more than $100 million in exposed agricultural crops. These 17 counties also contain more than 70 percent of the total value of exposed agricultural crops in the state. In addition, Humboldt, Marin, Plumas, Yolo, Del Norte, Contra Costa, San Joaquin, and Colusa counties have more than 50 percent of their agricultural acreage exposed to the 500-year floodplain.

Table F-6. Summary of Population Exposure Results by Analysis Region Category

Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than 10,000	No. Greater Than 50,000	No. Greater Than 100,000	No. Greater Than 250,000	No. Greater Than 1,000,000	No. Greater Than 10,000	No. Greater Than 50,000	No. Greater Than 100,000	No. Greater Than 250,000	No. Greater Than 1,000,000
Counties	58	29	8	3	0	0	35	23	15	7	2
State Assembly Districts	80	45	5	0	0	0	71	46	24	5	0
State Senate Districts	40	31	13	1	0	0	38	34	24	3	0
U.S. Congressional Districts	53	37	11	0	0	0	48	37	26	11	0
IRWM Regions	48	29	7	2	1	0	34	19	15	6	3

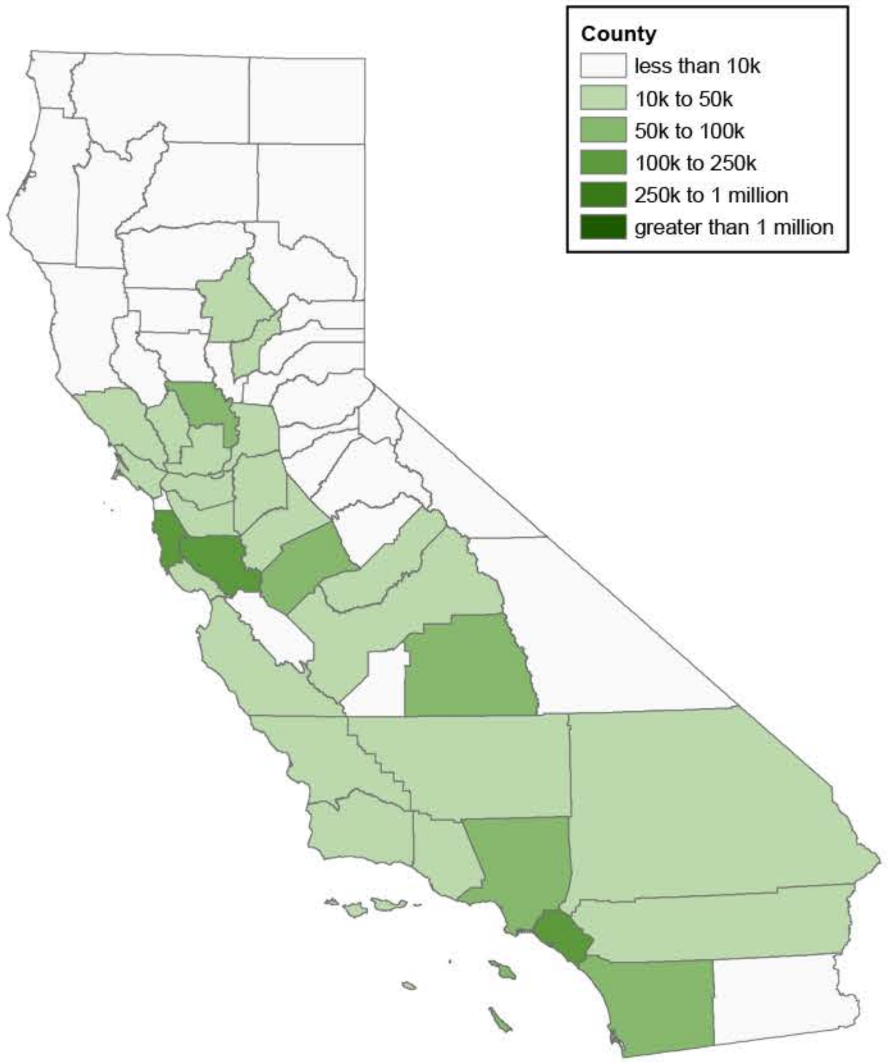
Table F-7. Summary of Structures and Contents Exposure Results by Analysis Region Category

Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than $1 Billion	No. Greater Than $5 Billion	No. Greater Than $10 Billion	No. Greater Than $20 Billion	No. Greater Than $50 Billion	No. Greater Than $1 Billion	No. Greater Than $5 Billion	No. Greater Than $10 Billion	No. Greater Than $20 Billion	No. Greater Than $50 Billion
Counties	58	28	9	3	0	0	33	21	14	6	3
State Assembly Districts	80	45	6	0	0	0	70	44	21	5	0
State Senate Districts	40	30	13	1	0	0	38	32	22	10	0
U.S. Congressional Districts	53	35	11	1	0	0	48	36	22	9	0
IRWM Regions	48	25	6	2	1	0	33	17	15	6	3

Table F-8. Summary of Agricultural Crops Exposure Results by Analysis Region Category

Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than $10 million	No. Greater Than $50 million	No. Greater Than $100 million	No. Greater Than $250 million	No. Greater Than $500 million	No. Greater Than $10 million	No. Greater Than $50 million	No. Greater Than $100 million	No. Greater Than $250 million	No. Greater Than $500 million
Counties	58	33	25	12	8	3	34	28	17	10	4
State Assembly Districts	80	23	20	14	6	3	26	21	17	10	3
State Senate Districts	40	15	12	9	7	4	18	14	10	9	6
U.S. Congressional Districts	53	20	15	11	7	4	21	15	14	10	5
IRWM Regions	48	28	19	14	6	2	28	24	16	10	5

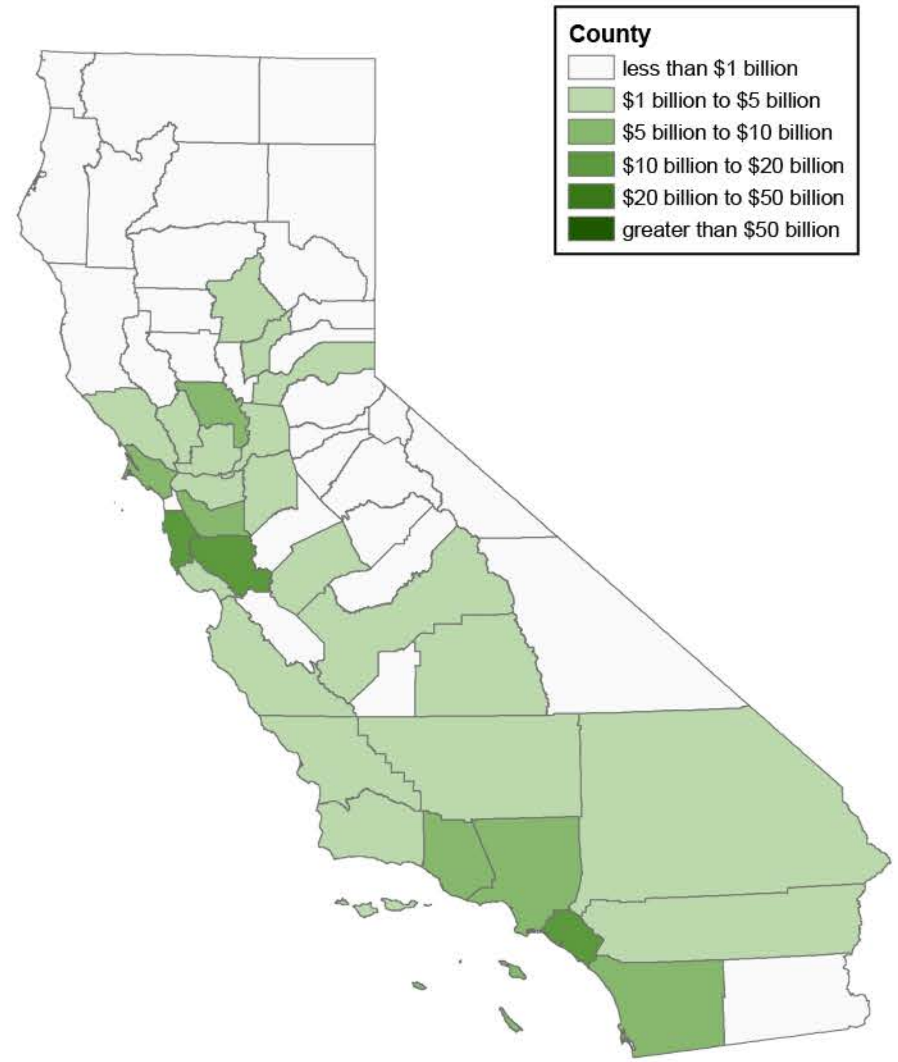
Population Exposed by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Population Exposed Statewide = 1.4 million (4%)

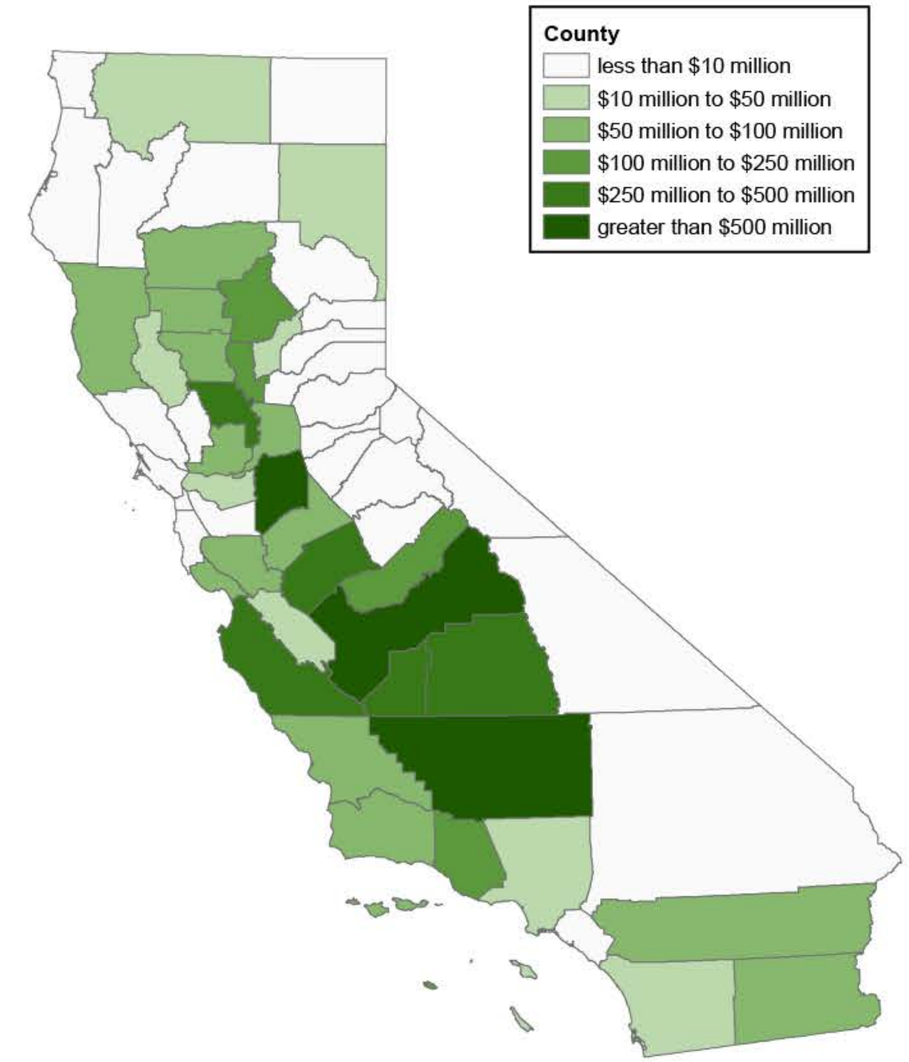
Value of Exposed Structures and Contents by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Value of Exposed Structures and Contents Statewide = $136.7 billion (5%)

Value of Exposed Agricultural Crops by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Value of Exposed Agricultural Crops = $5.4 billion (27%)

Figure F-11
Statewide Exposure to Flood Hazard, Reported by County for a 100-year Flood Event

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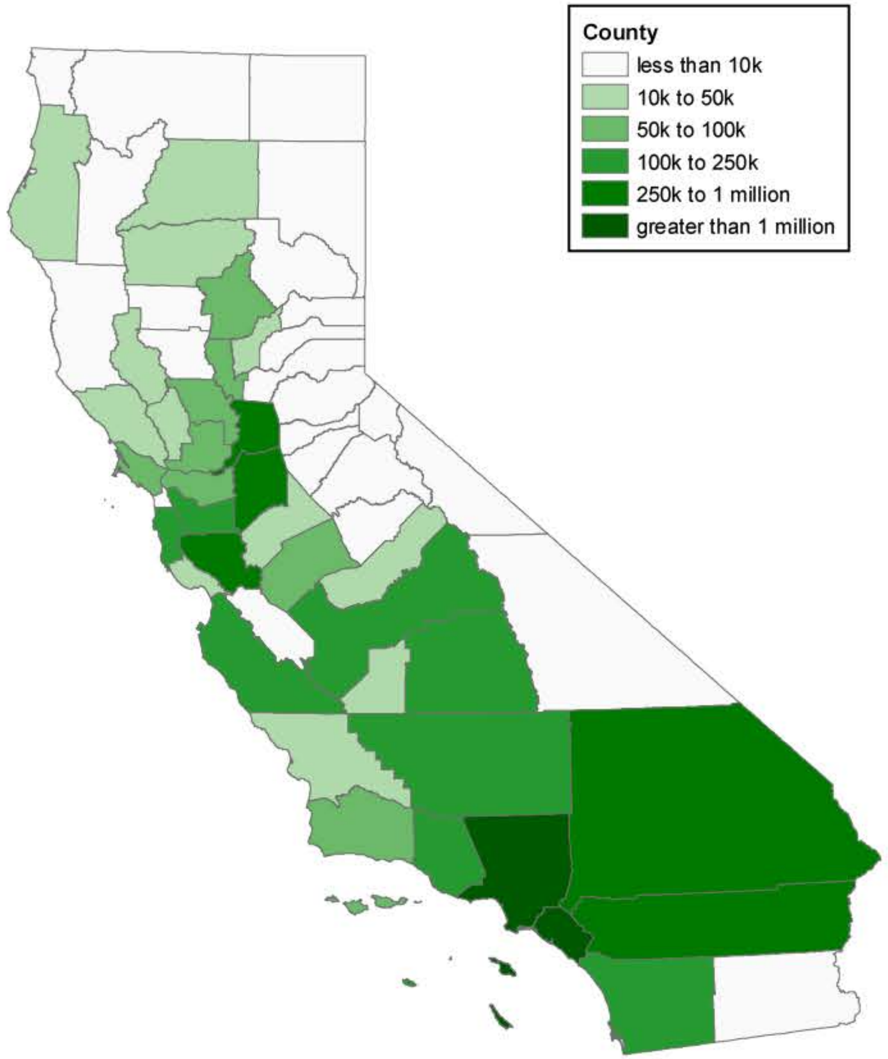
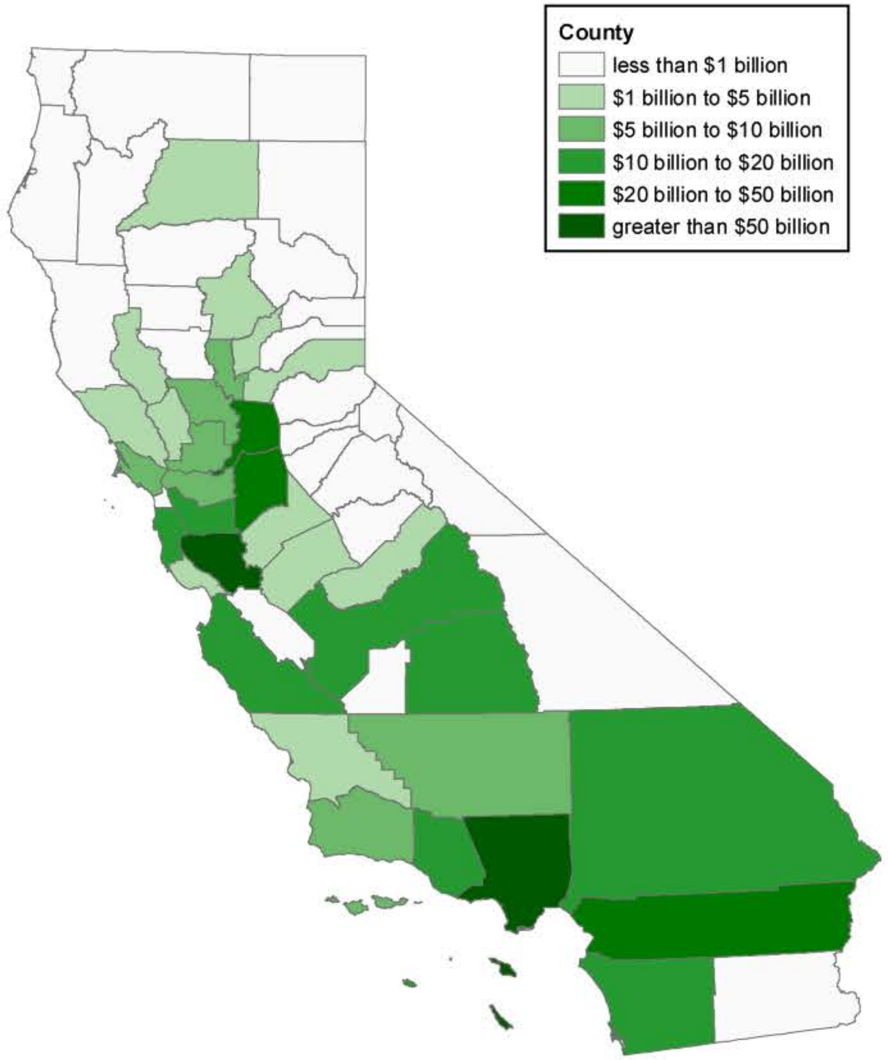
Population Exposed by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Population Exposed Statewide = 7.3 million (21%)

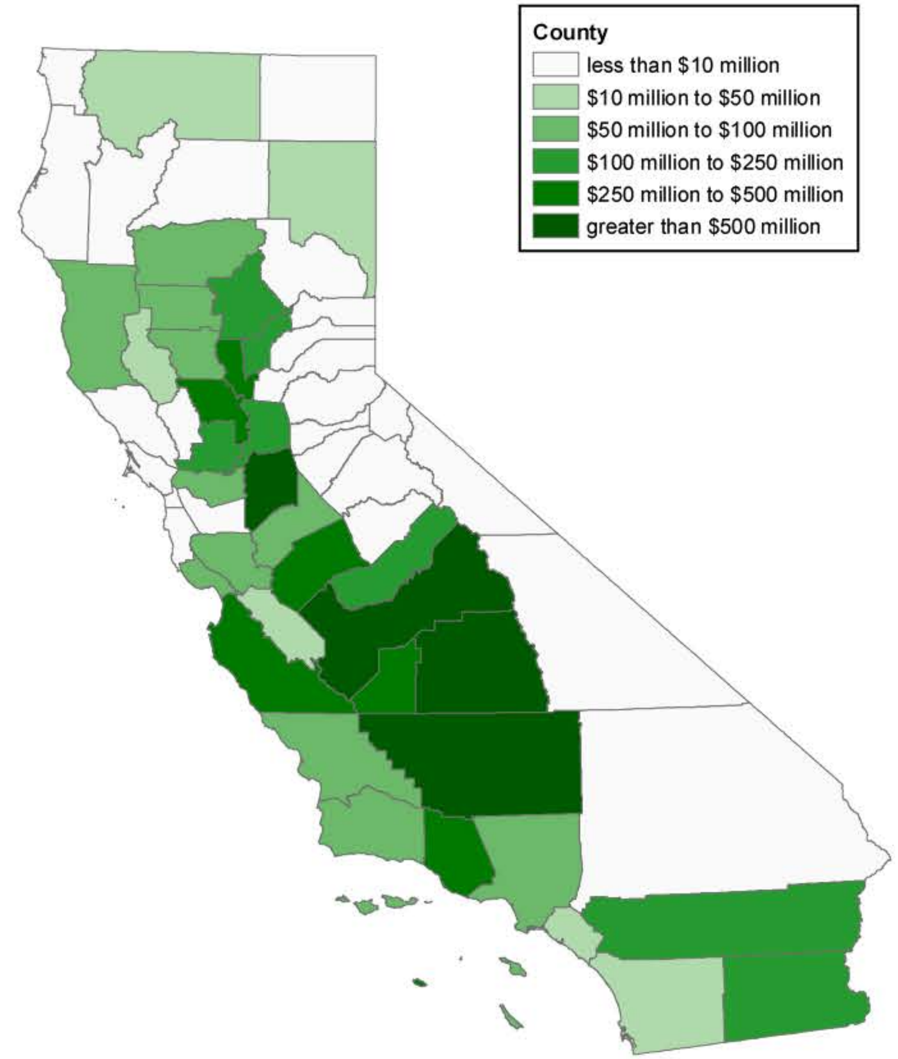
Value of Exposed Structures and Contents by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Value of Exposed Structures and Contents Statewide = $576.8 billion (20%)

Value of Exposed Agricultural Crops by County



NOTE: Each island is part of an analysis region that also includes an area on the mainland. For those analysis regions, the results shown reflect the total of the mainland area and its associated islands.

Total Value of Exposed Agricultural Crops = $7.5 billion (35%)

Figure F-12
Statewide Exposure to Flood Hazard, Reported by County for a 500-year Flood Event

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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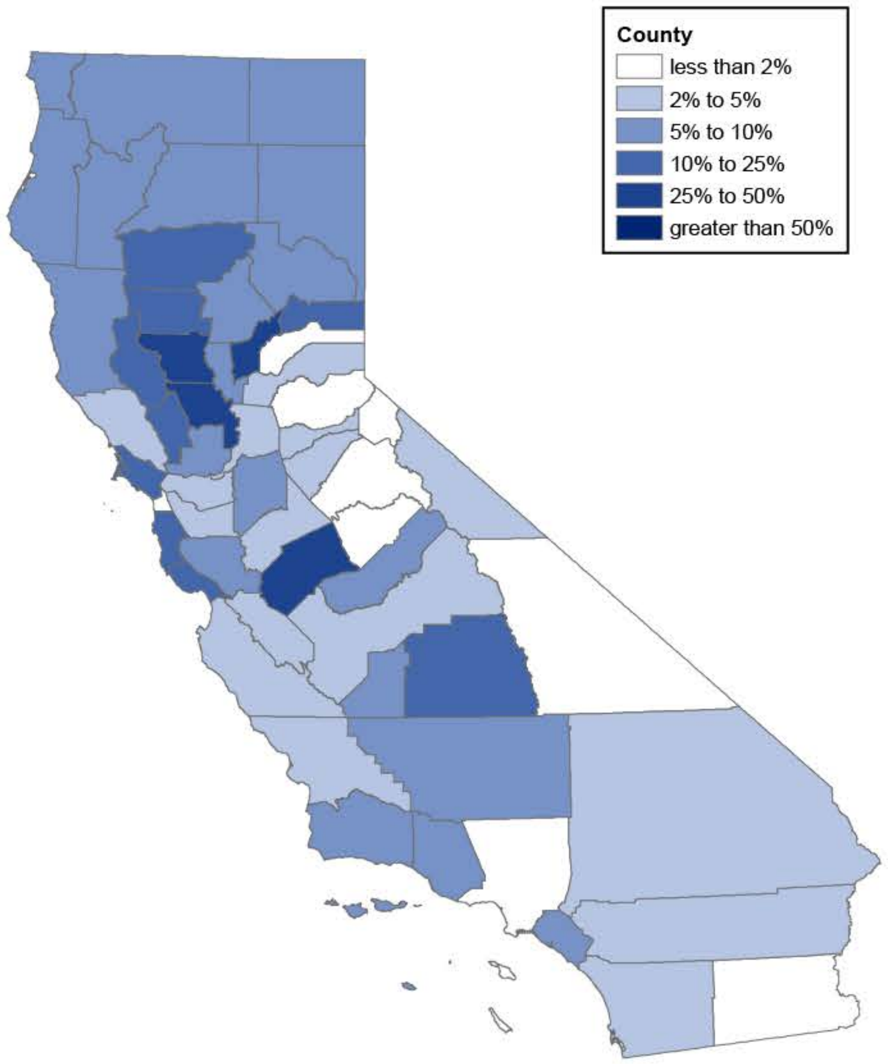
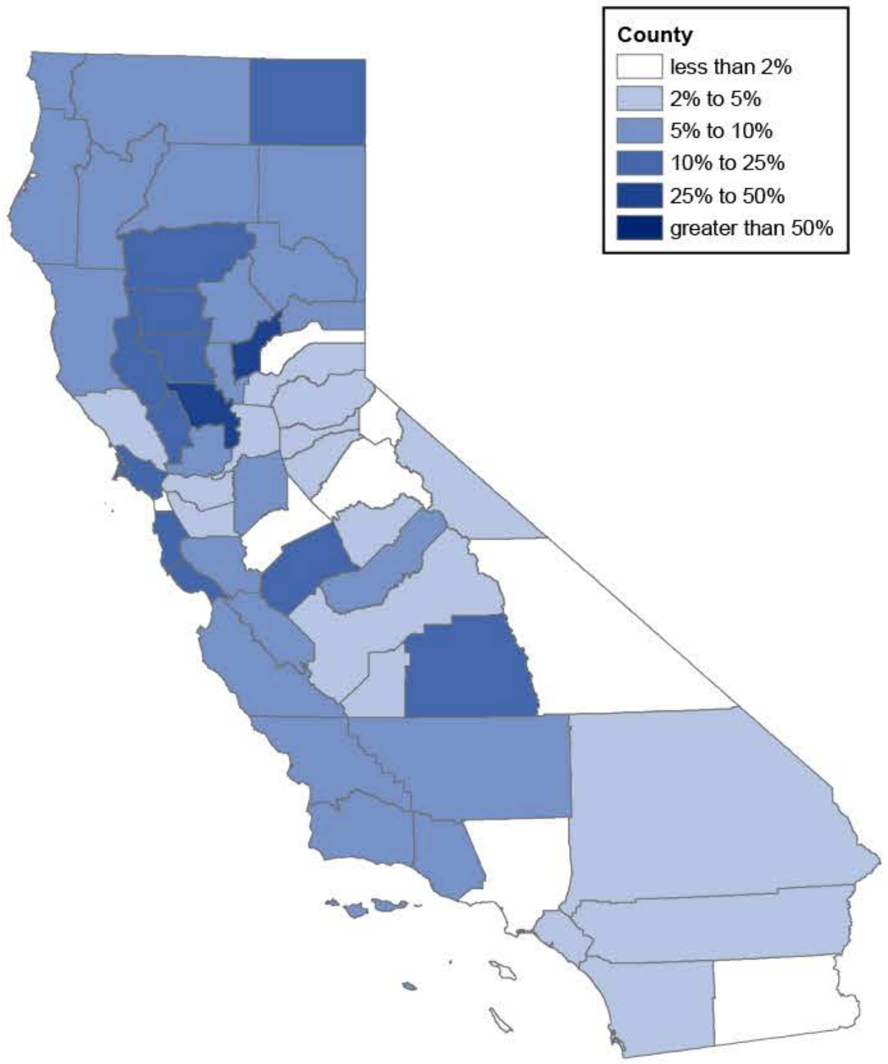
Percentage of Population Exposed by County



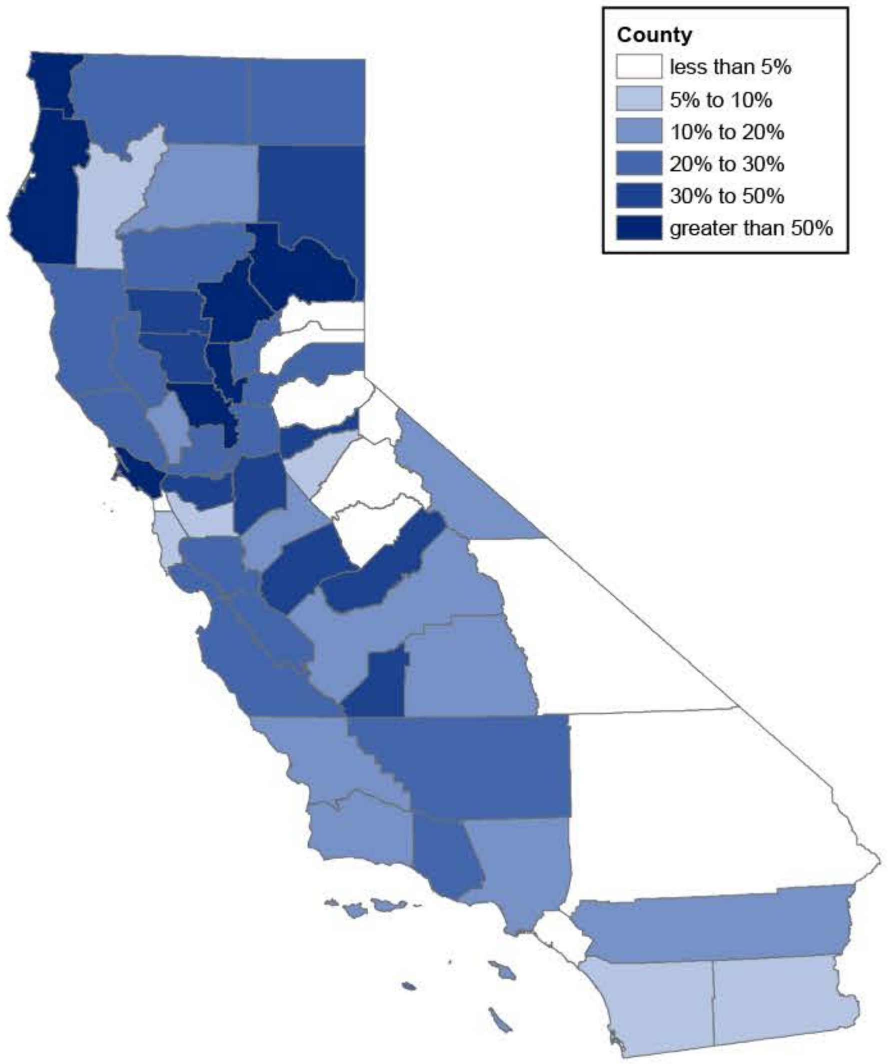
Percentage of Total Population Exposed Statewide = 4%

Percentage of Exposed Structures and Contents by County



Percentage of Total Exposed Structures and Contents Statewide = 5%

Percentage of Exposed Agricultural Crops by County



Percentage of Total Exposed Agricultural Crops Statewide = 27%

Figure F-13
Percentage of Statewide Exposure to Flood Hazard, Reported by County for a 100-year Flood Event

November 9, 2012

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM
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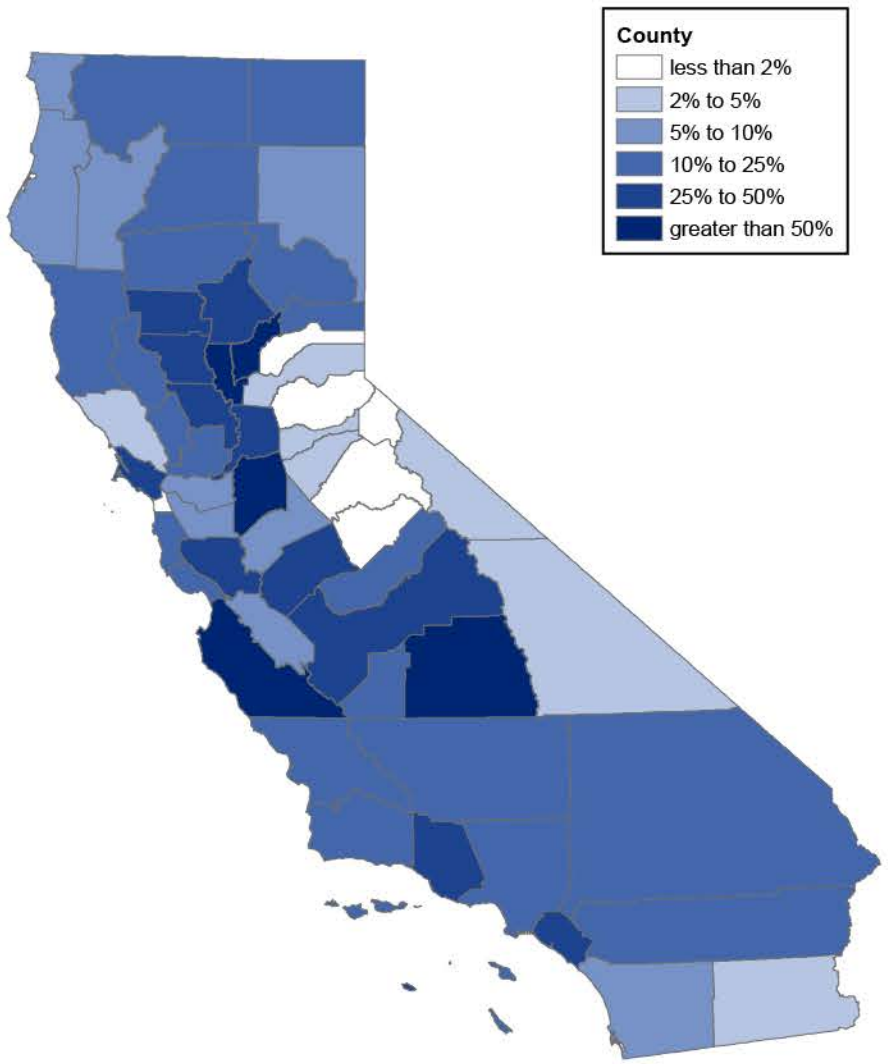
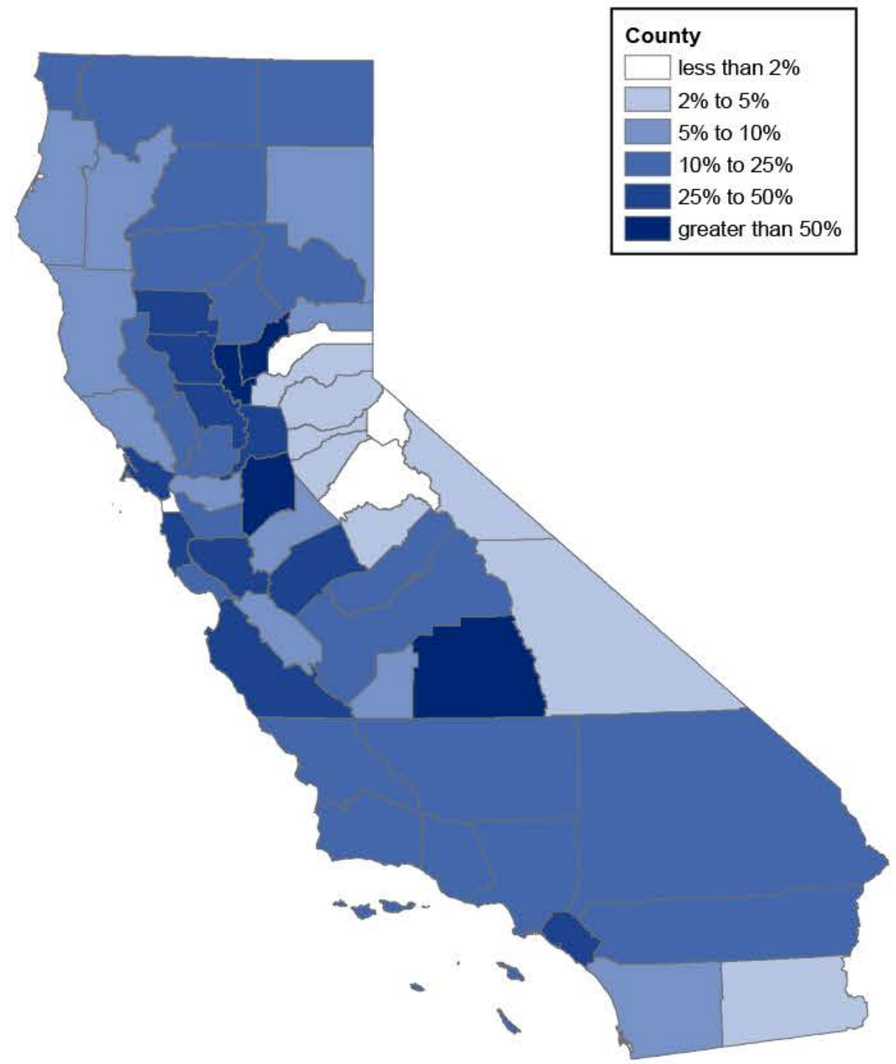
Percentage of Population Exposed by County



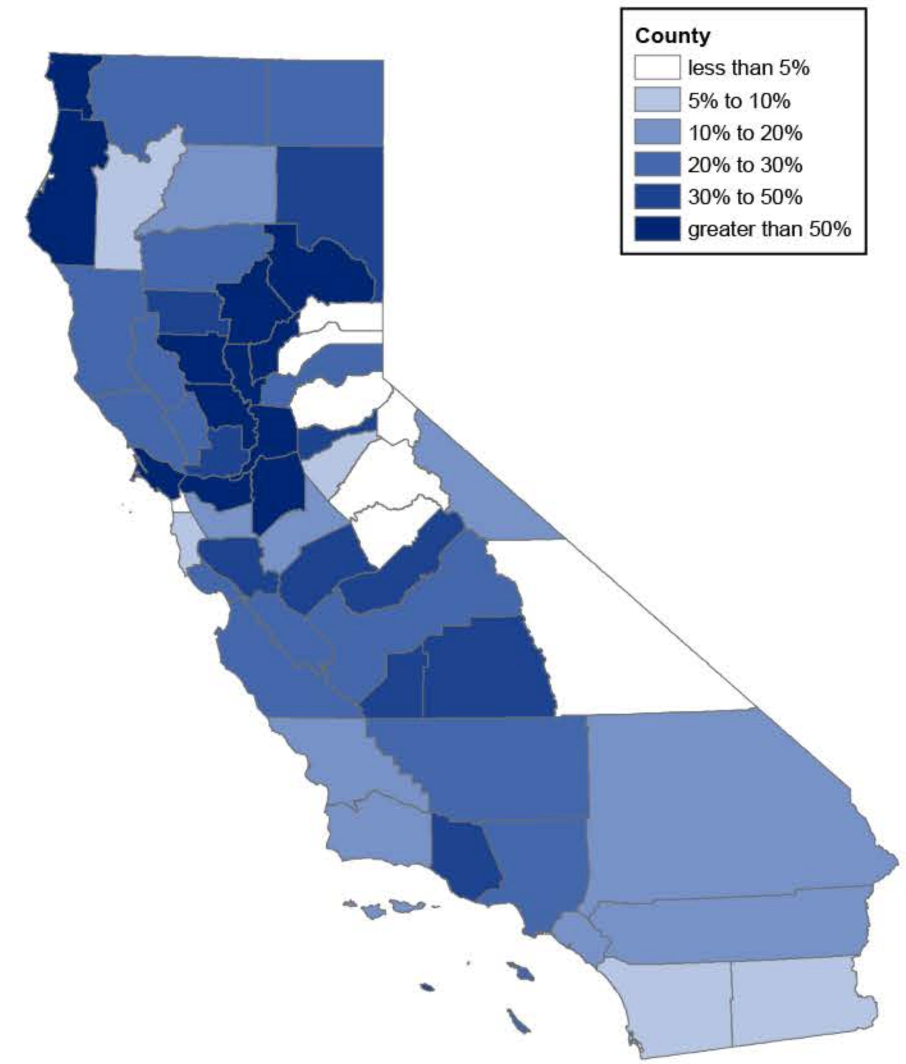
Percentage of Total Population Exposed Statewide = 21%

Percentage of Exposed Structures and Contents by County



Percentage of Total Exposed Structures and Contents Statewide = 20%

Percentage of Exposed Agricultural Crops by County



Percentage of Total Exposed Agricultural Crops Statewide = 35%

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Figure F-14
Percentage of Statewide Exposure to Flood Hazard, Reported by County for a 500-year Flood Event

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Exposure of sensitive plant species to flood hazard in the 100-year floodplain is distributed among most California counties, with 14 counties having more than 50 plant species exposed. San Diego and San Luis Obispo counties have the most exposure with more than 100 sensitive plant species in the 100-year floodplain.

Exposure of sensitive plant species to the 500-year floodplain is similar to that of the 100-year floodplain. Fourteen counties have more than 50 sensitive plant species in the 500-year floodplain, and San Diego and San Luis Obispo counties have more than 100 sensitive plant species in the 500-year floodplain.

For both the 100-year and 500-year floodplains, about 9 percent of the exposed sensitive plant species were listed by the State of California as endangered, and about 10 percent of the exposed plant species were Federally listed as endangered. For both the 100-year and 500-year floodplains, about 2 percent of the exposed sensitive plant species were listed by the State of California as threatened, and about 4 percent of exposed plant species were Federally listed as threatened.

Exposure of sensitive animal species to flood hazard in the 100-year floodplain is distributed among most California counties, with 16 counties having more than 50 animal species exposed. Riverside and San Bernardino counties have the most exposure with more than 100 animal species in the 100-year floodplain. Exposure of sensitive animal species to the 500-year floodplain is similar to that of the 100-year floodplain. Seventeen counties have more than 50 sensitive animal species in the 500-year floodplain, and Riverside and San Bernardino counties have more than 100 sensitive animal species in the 500-year floodplain.

For both the 100-year and 500-year floodplains, about 8 percent of the exposed animal species were listed by the State of California as endangered, and about 12 percent of the exposed animal species were Federally listed as endangered. For both the 100-year and 500-year floodplains, about 6 percent of the exposed animal species were listed by the State of California as threatened, and about 5 percent of exposed animal species were Federally listed as threatened.

4.1.2 State Assembly, State Senate, and U.S. Congressional Districts

Tables F-6, F-7, and F-8, and Figures F-15 and F-16 show the exposure results for the State assembly districts in terms of population, value of structures and their contents, and value of agricultural crops in the 100-year and 500-year floodplains. Figures F-17 and F-18 present that information for State senate districts, while Figures F-19 and F-20 present the information for U.S. congressional districts.

Urban exposure to flood hazard for the 100-year floodplain is highly distributed across the state among the political districts. Forty-five assembly districts, 31 senate districts, and 37 congressional districts have more than 10,000 people exposed; similarly, 45 assembly districts, 30 senate districts, and 35 congressional districts each have more than $1 billion in structures and their contents exposed. Urban exposure to the 500-year floodplain is more concentrated than for the 100-year floodplain. Twenty-four assembly districts, 24 senate districts, and 26 congressional districts each have populations of more than 100,000 exposed. Twenty-one assembly districts, 22 senate districts, and 22 congressional districts have more than $10 billion in structures and their contents exposed to the 500-year floodplain.

Most of the exposure of agricultural crops to the 100-year floodplain occurs in 14 assembly districts, 9 senate districts, and 11 congressional districts, each of which has more than $100 million in exposed agricultural crops. These districts make up more than 80 percent of the total value of exposed agricultural crops for their respective categories in the state. Exposure of agricultural crops to the 500-year floodplain is concentrated in 10 senate districts, 17 assembly districts, and 14 congressional districts, each of which has more than $100 million in exposed agricultural crops. These districts also make up more than 80 percent of the total value of exposed agricultural crops for their respective categories in the state.

Exposure of sensitive species to flood hazard in the 100-year floodplain is distributed across the state among the political districts. Five assembly districts, seven senate districts, and five congressional districts have more than 100 sensitive plant species in the 100-year floodplain. Three assembly districts, six senate districts, and five congressional districts have more than 100 sensitive animal species in the 100-year floodplain. In the 500-year floodplain, five assembly districts, seven senate districts, and six congressional districts have more than 100 sensitive plant species exposed. Three assembly districts, six senate districts, and five congressional districts have more than 100 sensitive animal species in the 500-year floodplain.

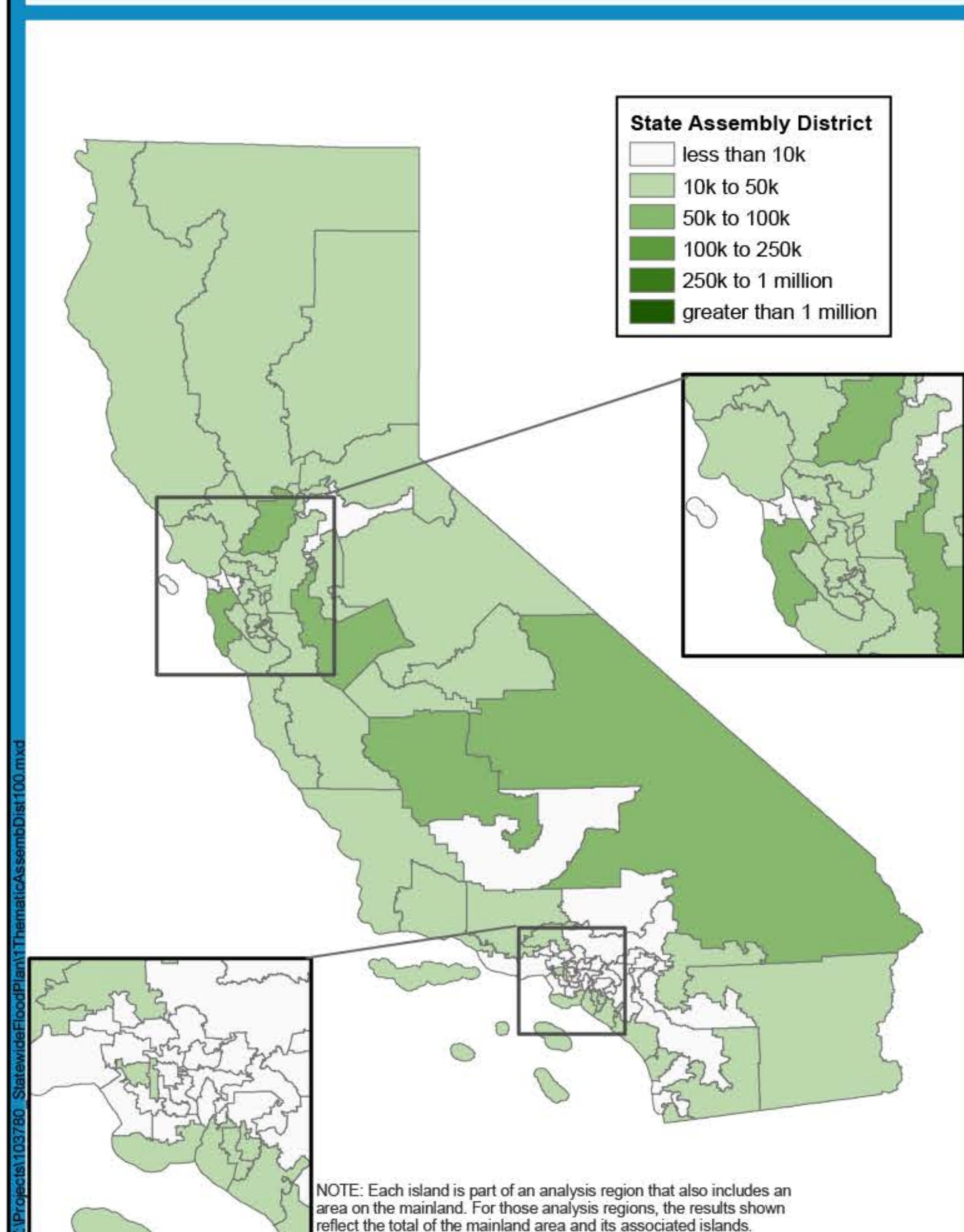
For both the 100-year and 500-year floodplains, about 9 percent of the exposed plant species were listed by the State of California as endangered, and about 10 percent of the exposed plant species were Federally listed as endangered. For both the 100-year and 500-year floodplains, about 2 percent of the exposed plant species were listed by the State of California as threatened, and about 4 percent of exposed plant species were Federally-listed as threatened.

For both the 100-year and 500-year floodplains, about 8 percent of the exposed animal species were listed by the State of California as endangered, and about 12 percent of the exposed animal species were Federally listed as endangered. For both the 100-year and 500-year floodplains, about 6 percent of the exposed animal species were listed by the State of California as threatened, and about 5 percent of exposed animal species were Federally listed as threatened.

4.1.3 IRWM Regions

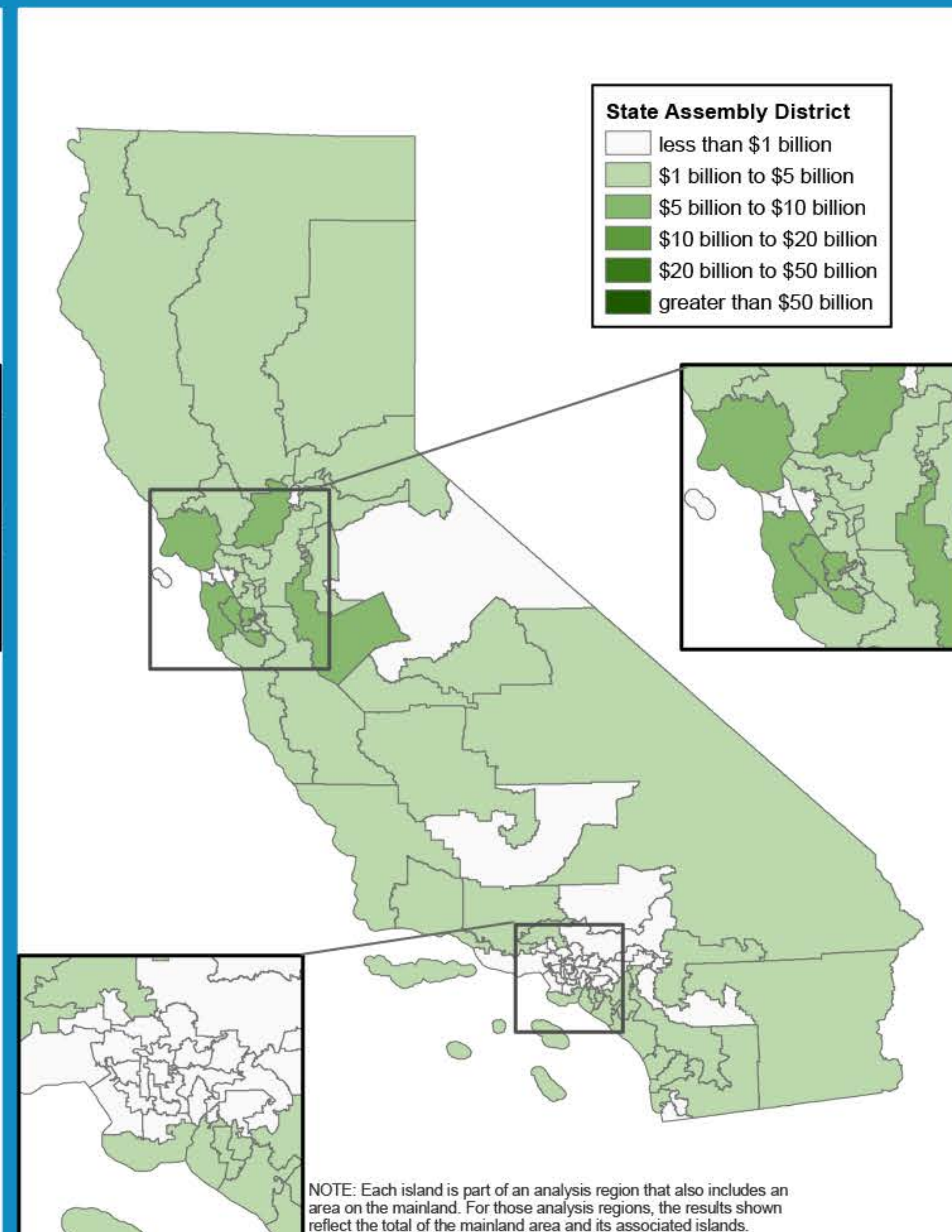
Tables F-6, F-7, and F-8 and Figures F-21 and F-22 show the relative differences between the 48 IRWM regions in population, value of structures and their contents, and value of agricultural crops in the 100-year and 500-year floodplains.

Population Exposed by State Assembly District



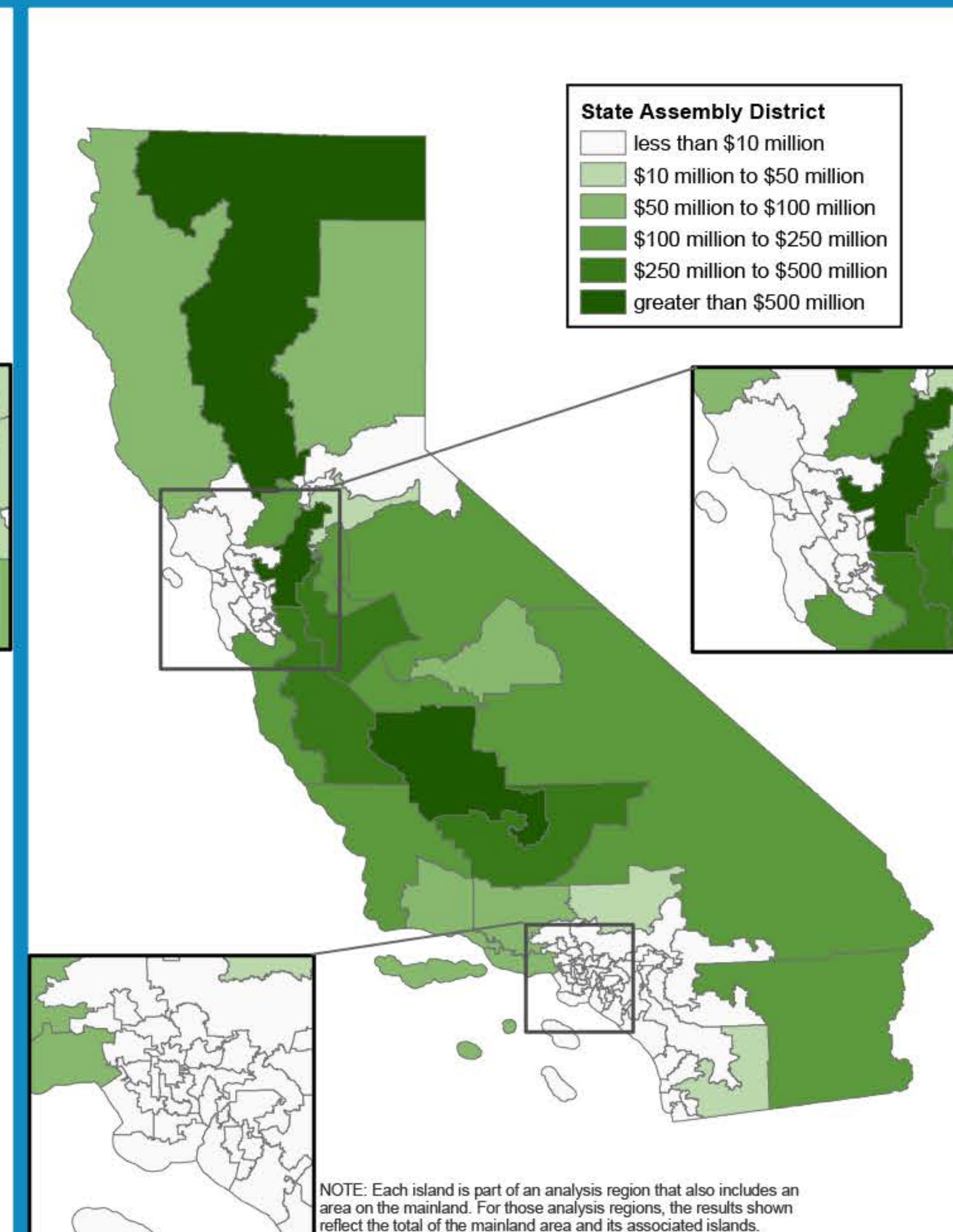
Total Population Exposed Statewide = 1.4 million

Value of Exposed Structures and Contents by State Assembly District



Total Value of Exposed Structures and Contents Statewide = $136.7 billion

Value of Exposed Agricultural Crops by State Assembly District



Total Value of Exposed Agricultural Crops = $5.4 billion

Figure F-15
Statewide Exposure to Flood Hazard, Reported by State Assembly District for a 100-year Flood Event

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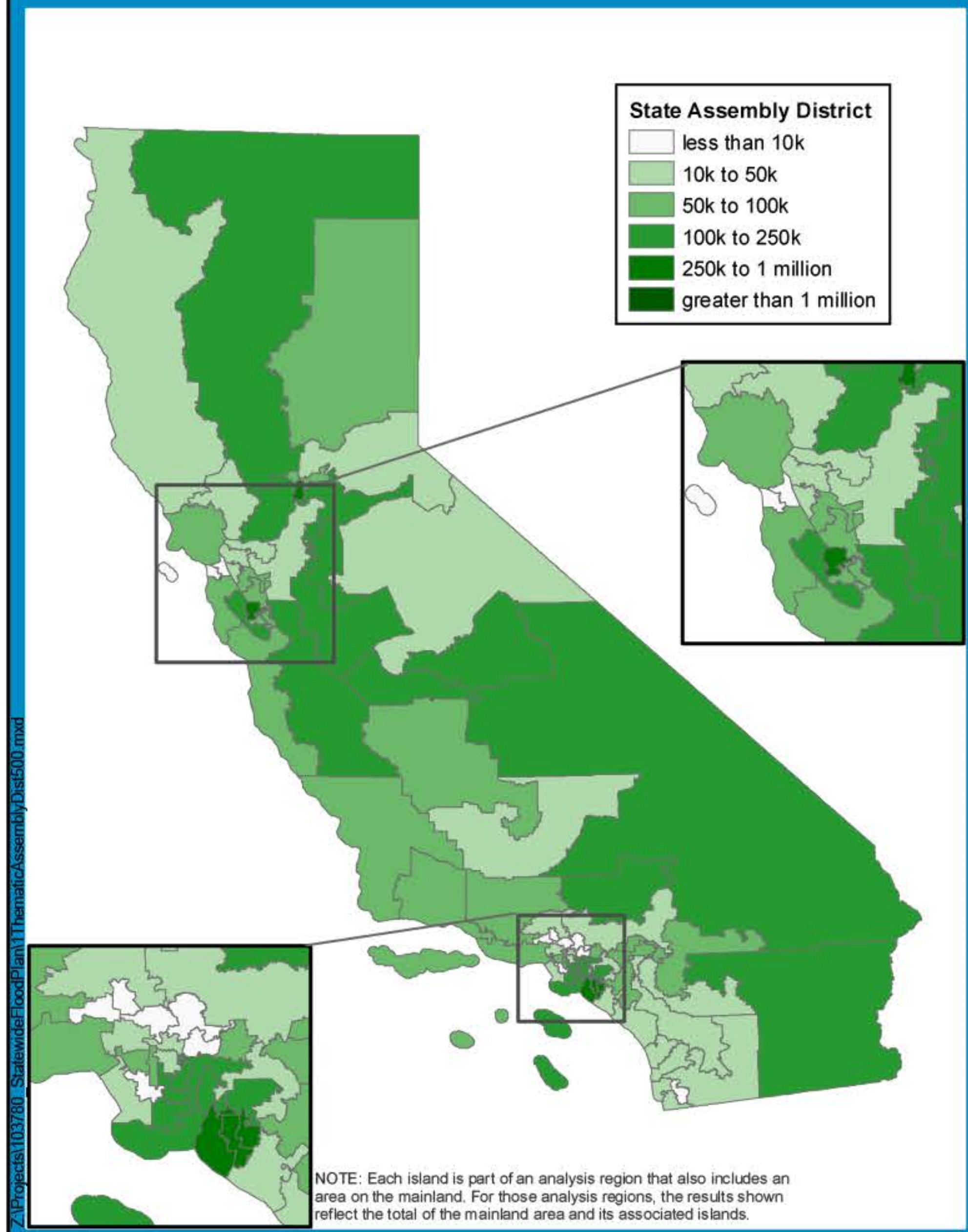
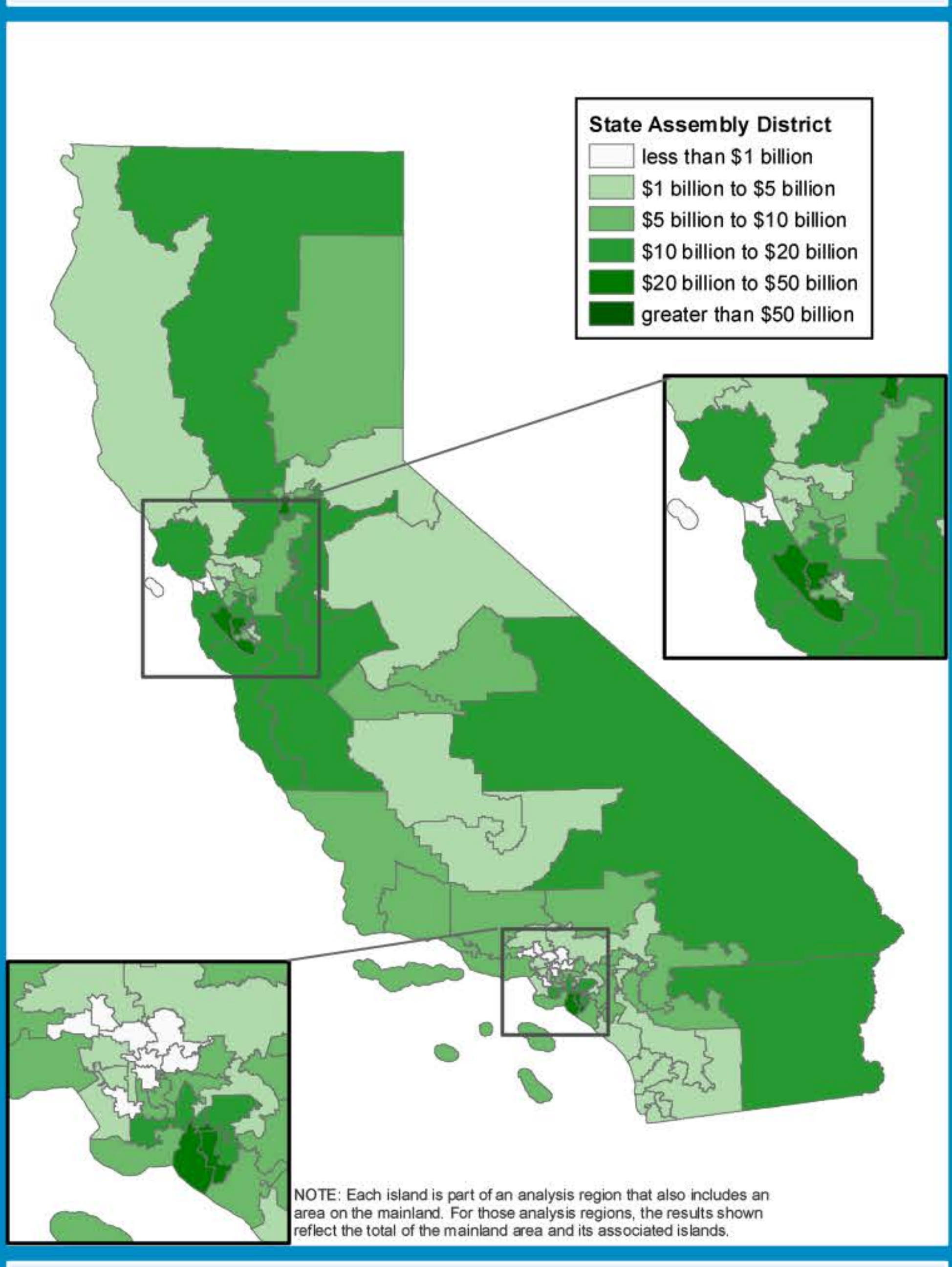
Population Exposed by State Assembly District



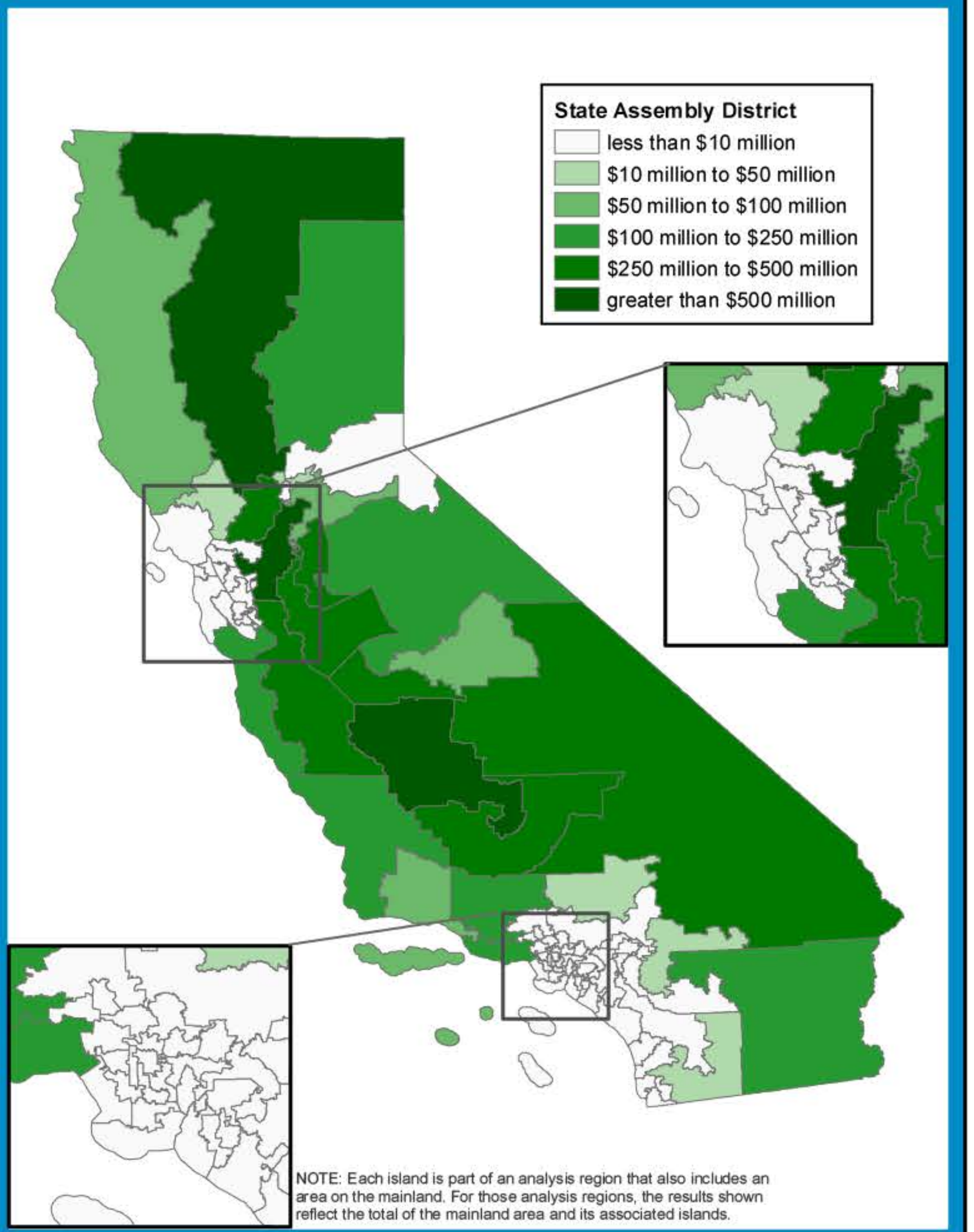
Total Population Exposed Statewide = 7.3 million

Value of Exposed Structures and Contents by State Assembly District



Total Value of Exposed Structures and Contents Statewide = $576.8 billion

Value of Exposed Agricultural Crops by State Assembly District



Total Value of Exposed Agricultural Crops = $7.5 billion

Figure F-16
Statewide Exposure to Flood Hazard, Reported by State Assembly District for a 500-year Flood Event

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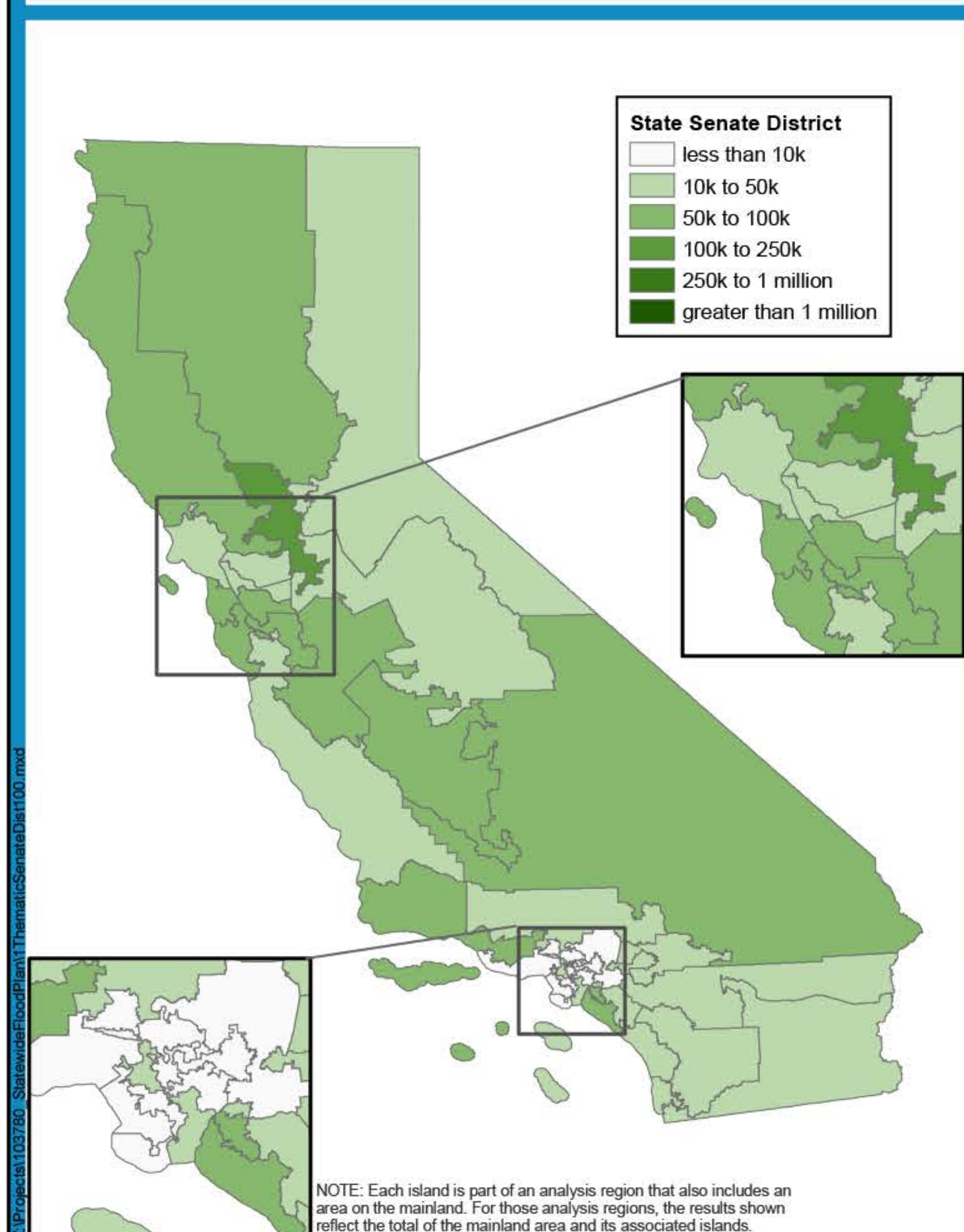
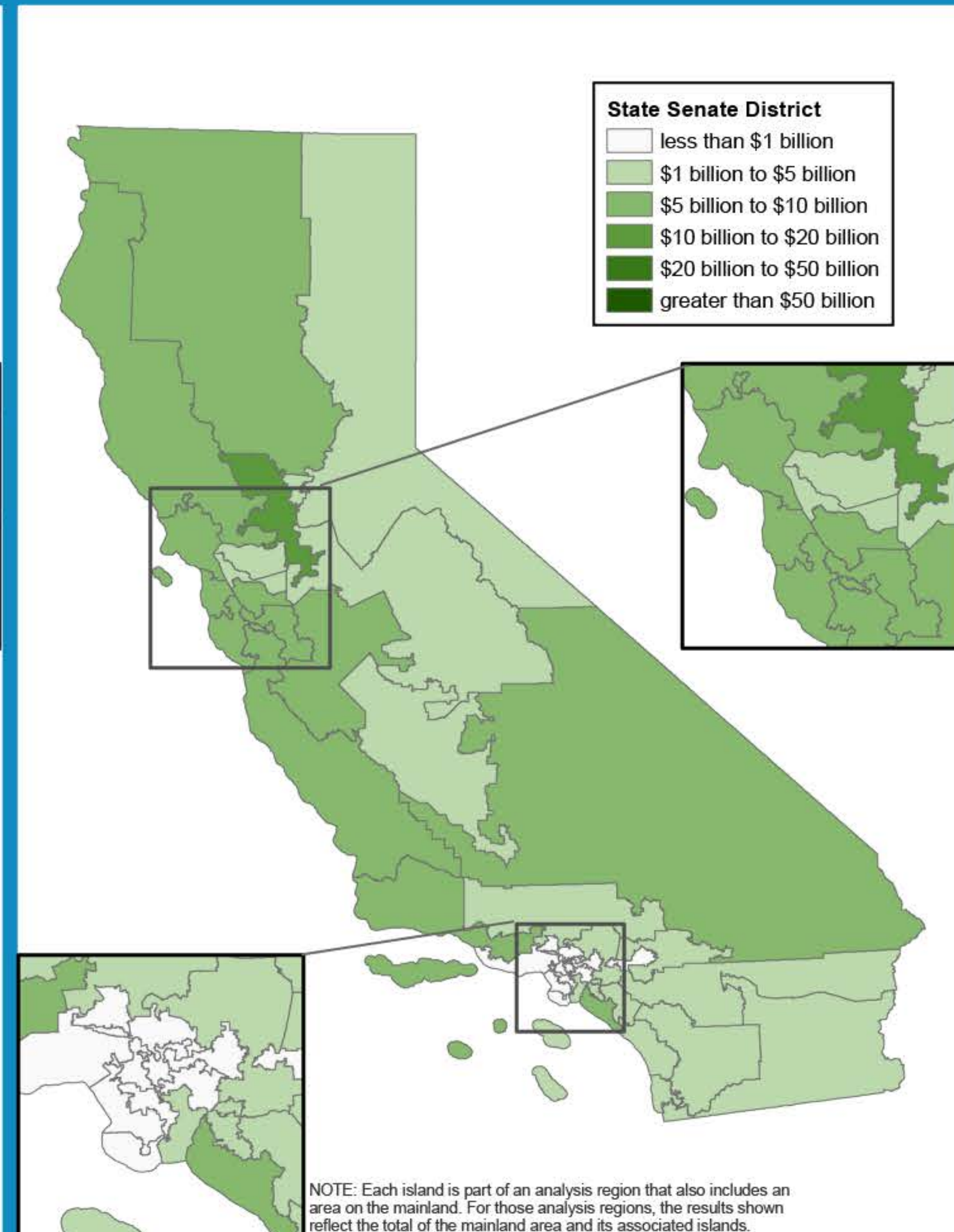
Population Exposed by State Senate District



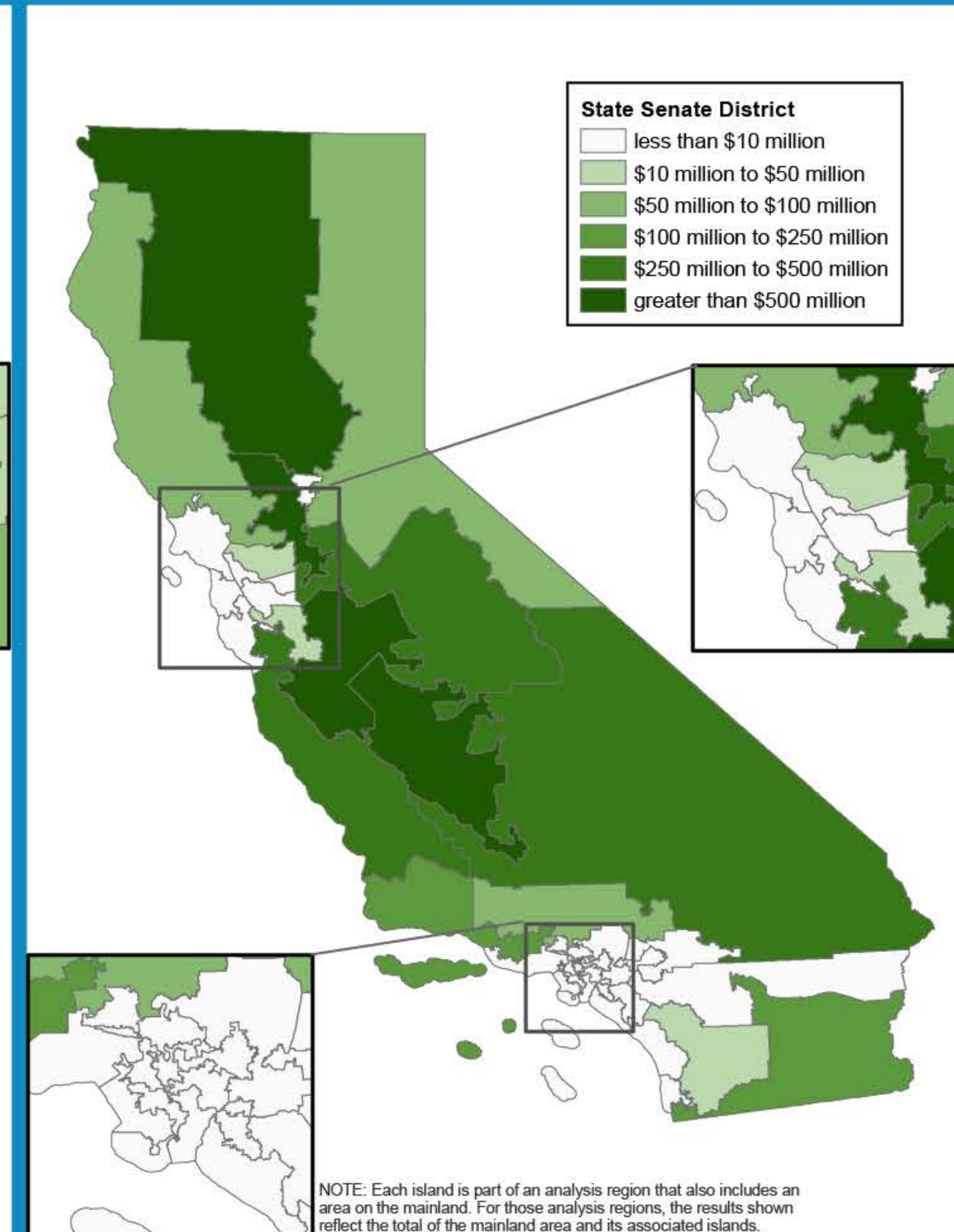
Total Population Exposed Statewide = 1.4 million

Value of Exposed Structures and Contents by State Senate District



Total Value of Exposed Structures and Contents Statewide = $136.7 billion

Value of Exposed Agricultural Crops by State Senate District



Total Value of Exposed Agricultural Crops = $5.4 billion

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Figure F-17
Statewide Exposure to Flood Hazard, Reported by State Senate District for a 100-year Flood Event

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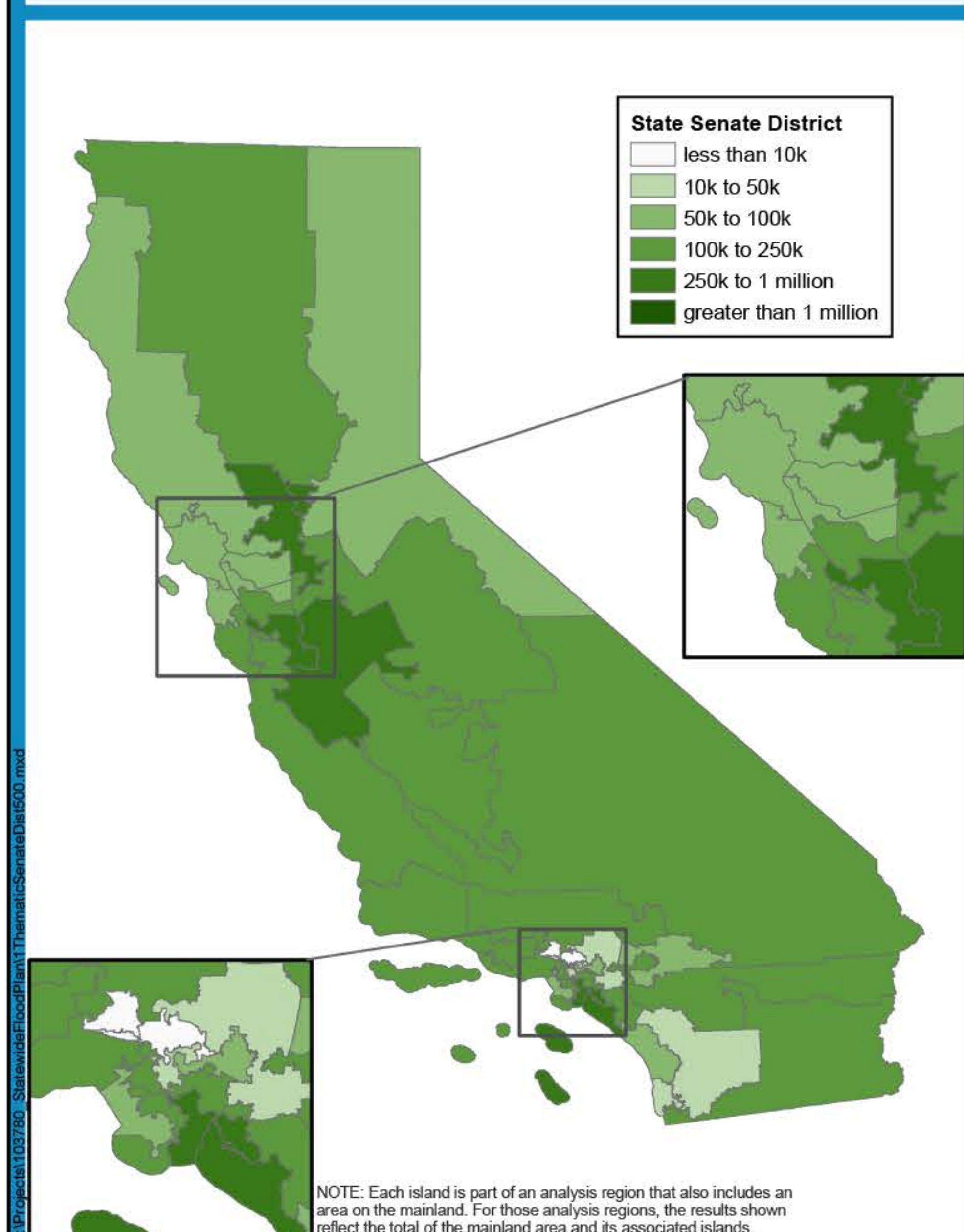
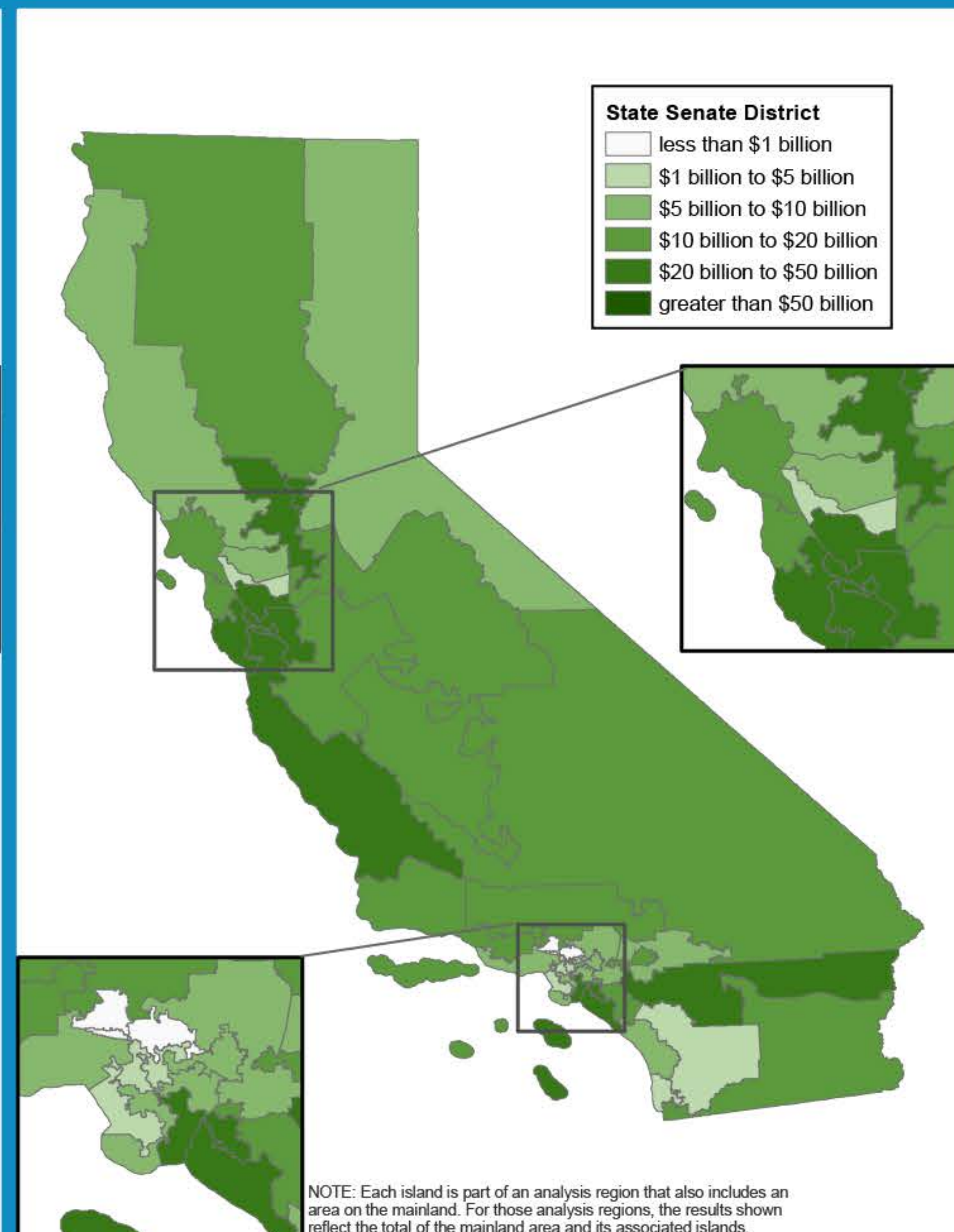
Population Exposed by State Senate District



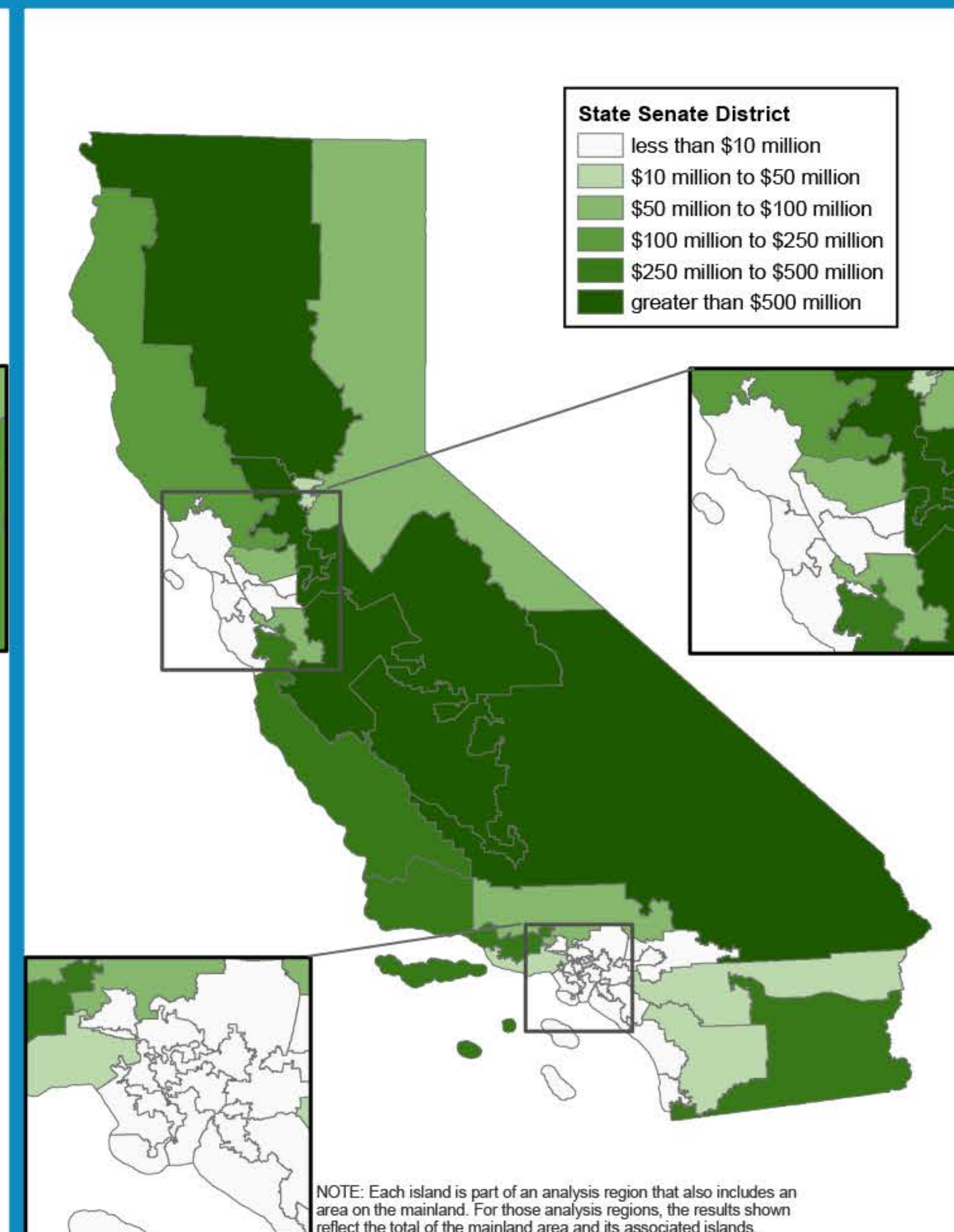
Total Population Exposed Statewide = 7.3 million

Value of Exposed Structures and Contents by State Senate District



Total Value of Exposed Structures and Contents Statewide = $577.8 billion

Value of Exposed Agricultural Crops by State Senate District



Total Value of Exposed Agricultural Crops = $7.4 billion

Figure F-18
Statewide Exposure to Flood Hazard, Reported by State Senate District for a 500-year Flood Event

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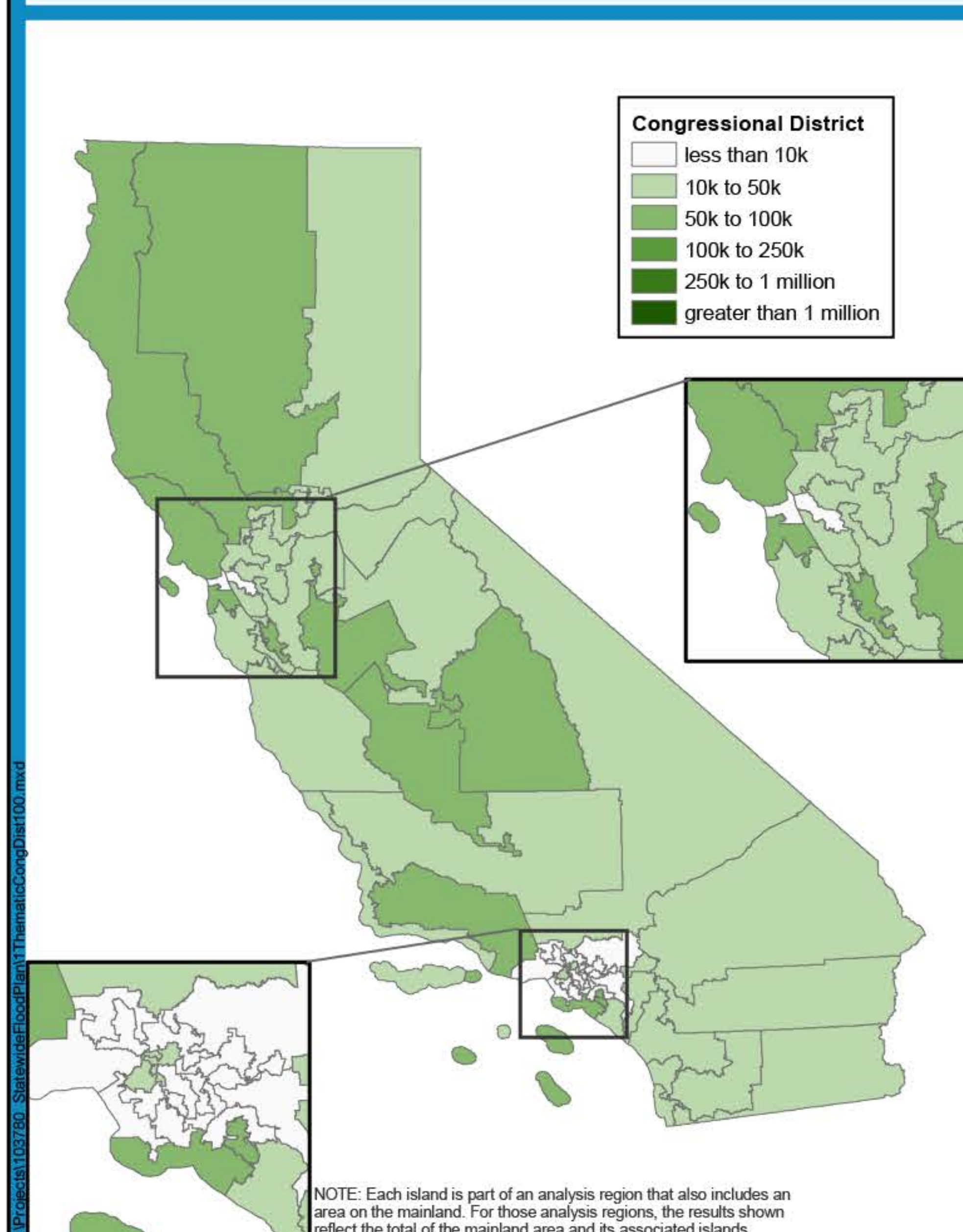
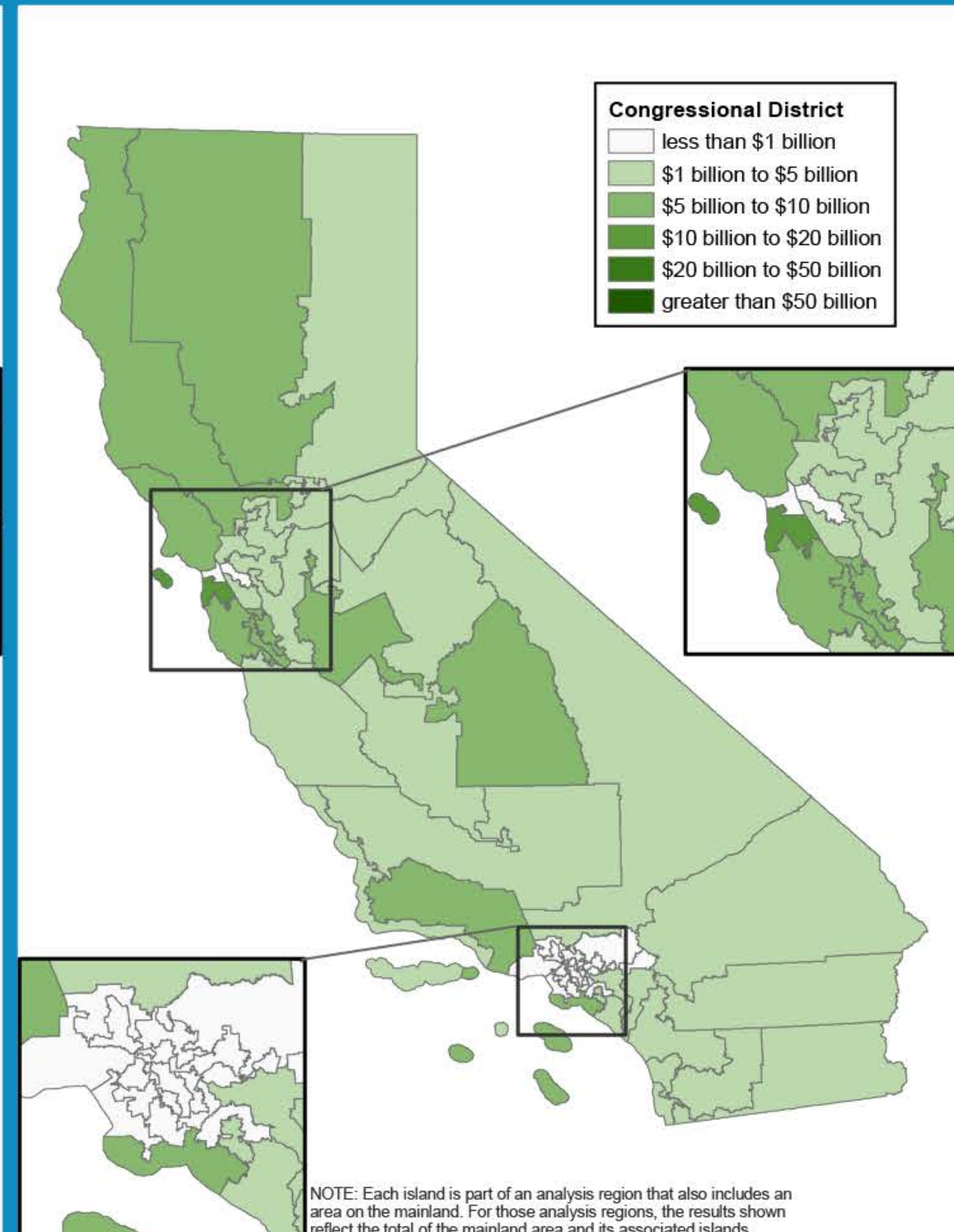
Population Exposed by Congressional District



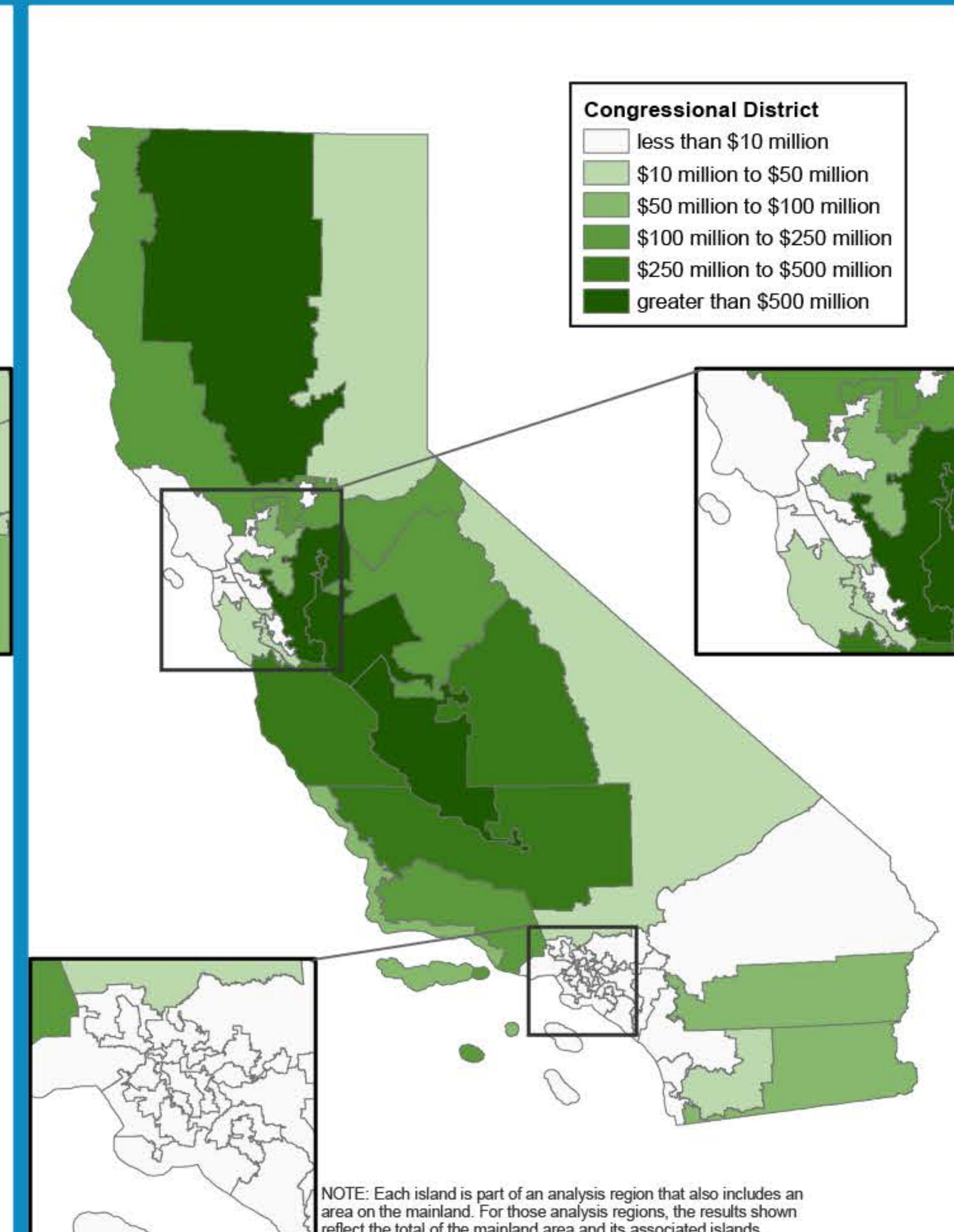
Total Population Exposed Statewide = 1.4 million

Value of Exposed Structures and Contents by Congressional District



Total Value of Exposed Structures and Contents Statewide = $136.7 billion

Value of Exposed Agricultural Crops by Congressional District



Total Value of Exposed Agricultural Crops = $5.4 billion

Figure F-19
Statewide Exposure to Flood Hazard, Reported by U.S. Congressional District for a 100-year Flood Event

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STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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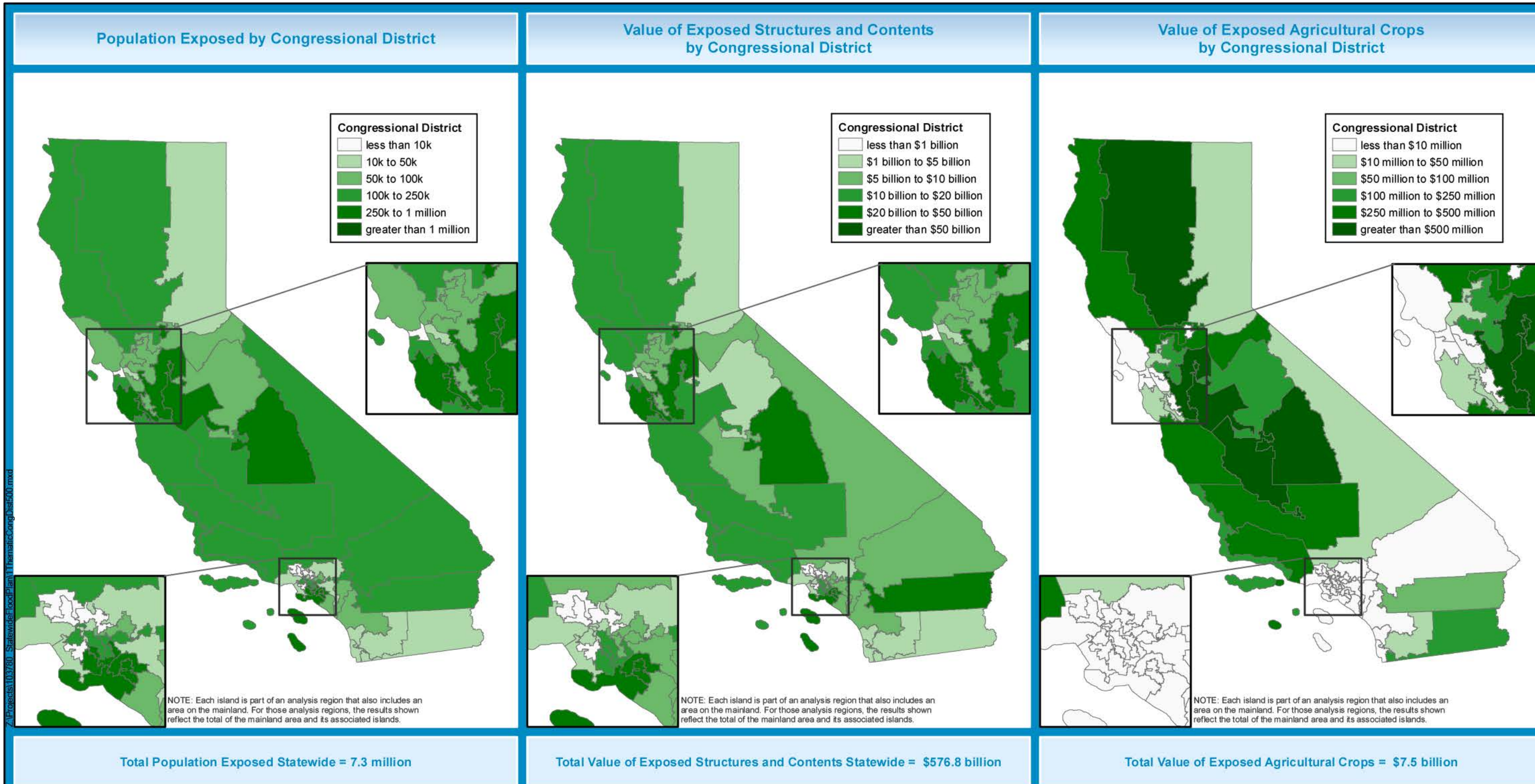

Figure F-20
Statewide Exposure to Flood Hazard, Reported by U.S. Congressional District for a 500-year Flood Event

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STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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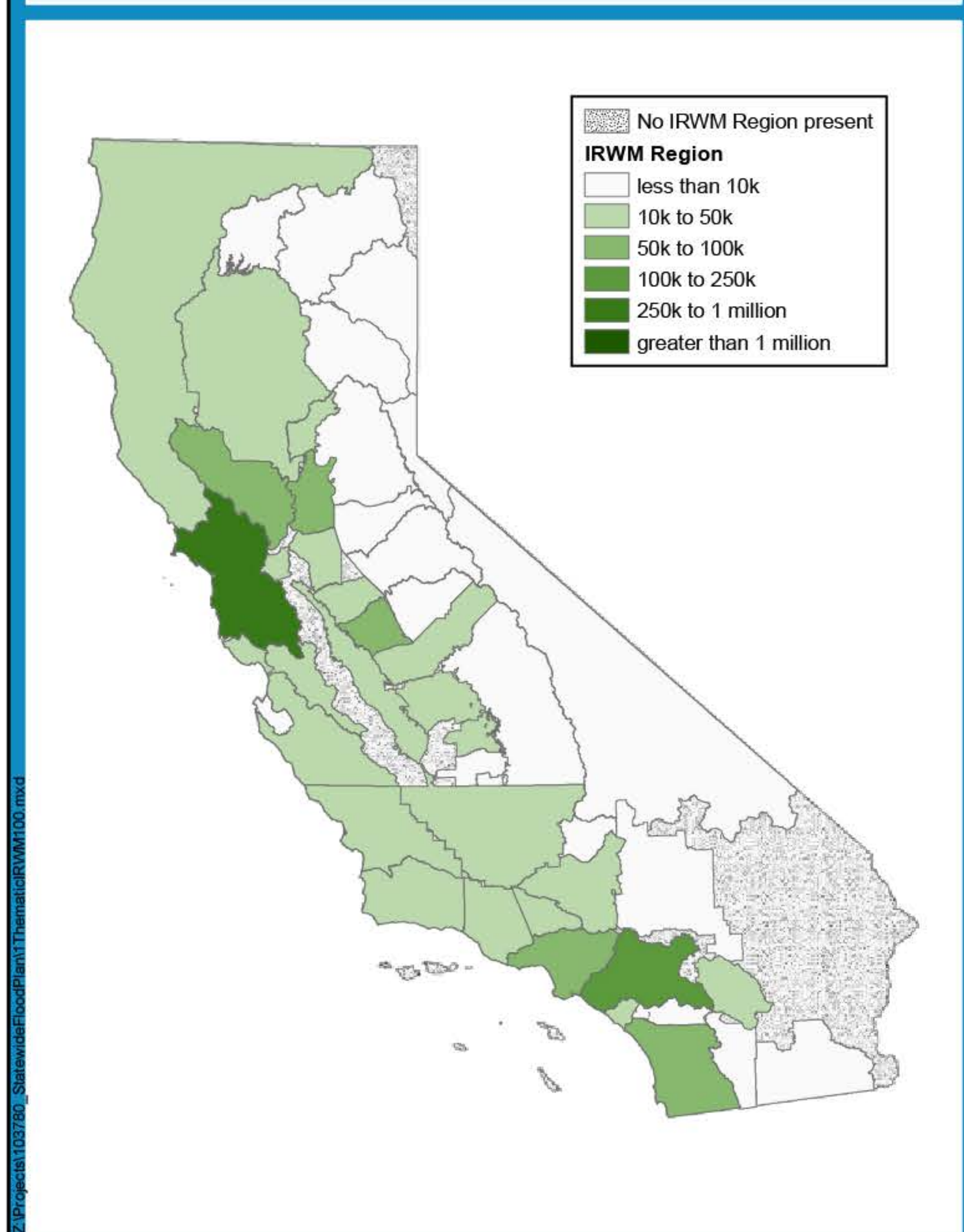
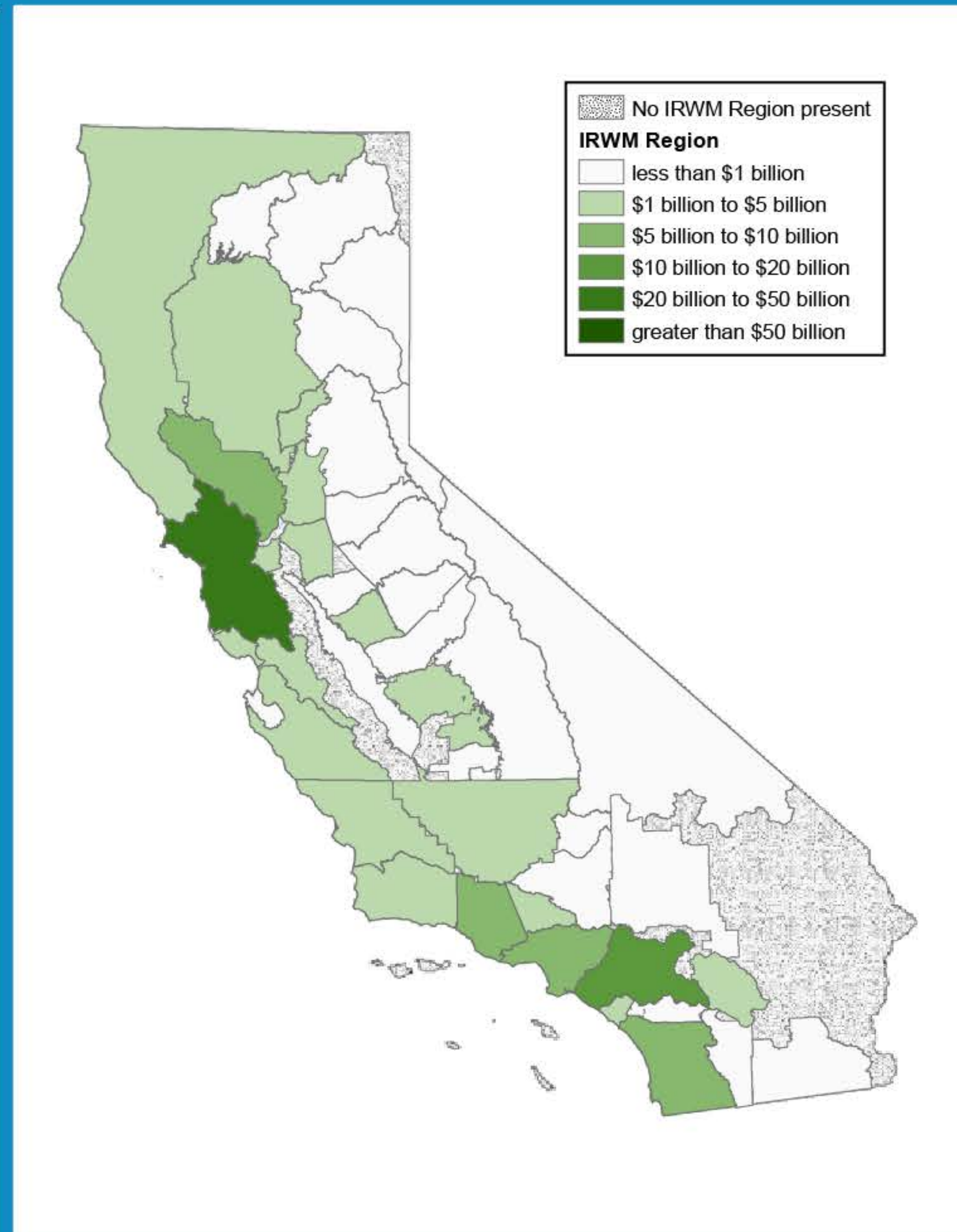
Population Exposed by IRWM Region



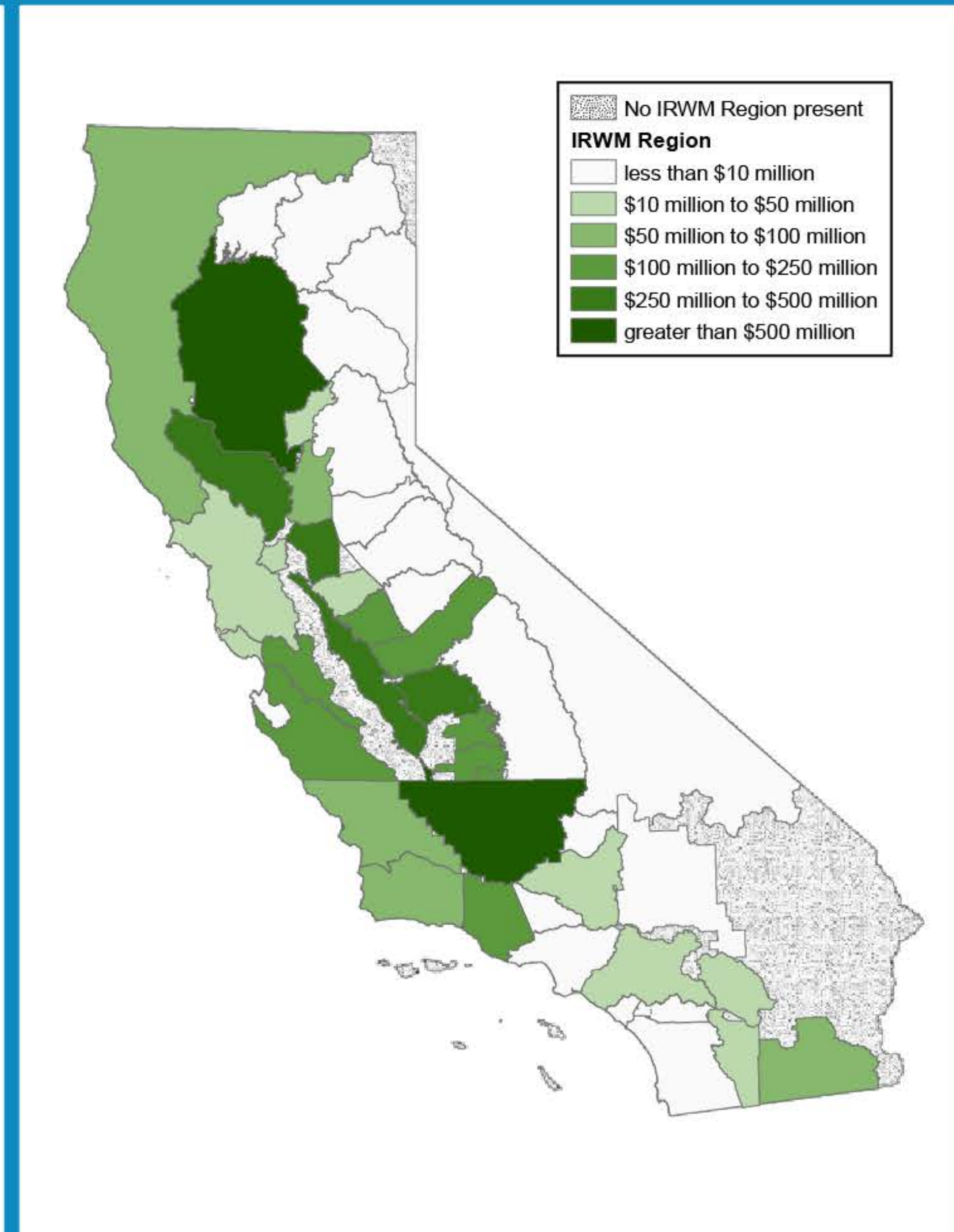
Total Population Exposed Statewide = 1.4 million

Value of Exposed Structures and Contents by IRWM Region



Total Value of Exposed Structures and Contents Statewide = $136.7 billion

Value of Exposed Agricultural Crops by IRWM Region



Total Value of Exposed Agricultural Crops = $5.4 billion

Figure F-21
Statewide Exposure to Flood Hazard, Reported by IRWM Region for a 100-year Flood Event

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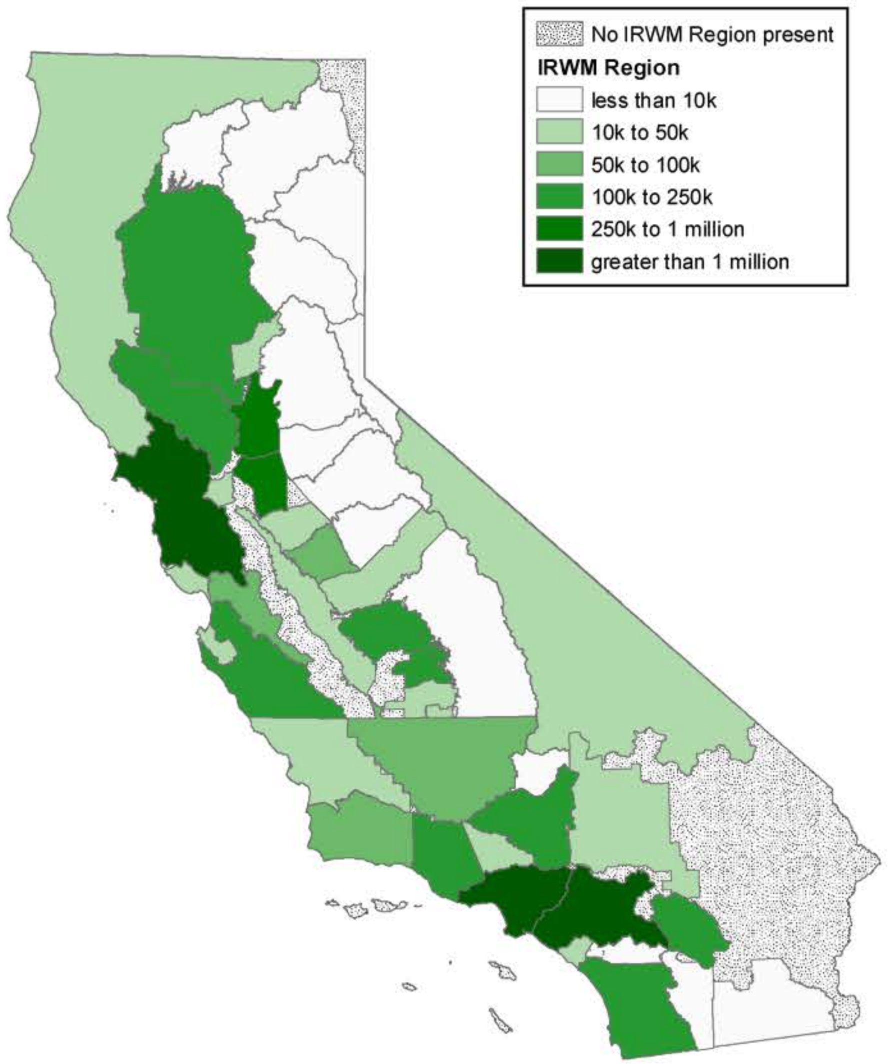
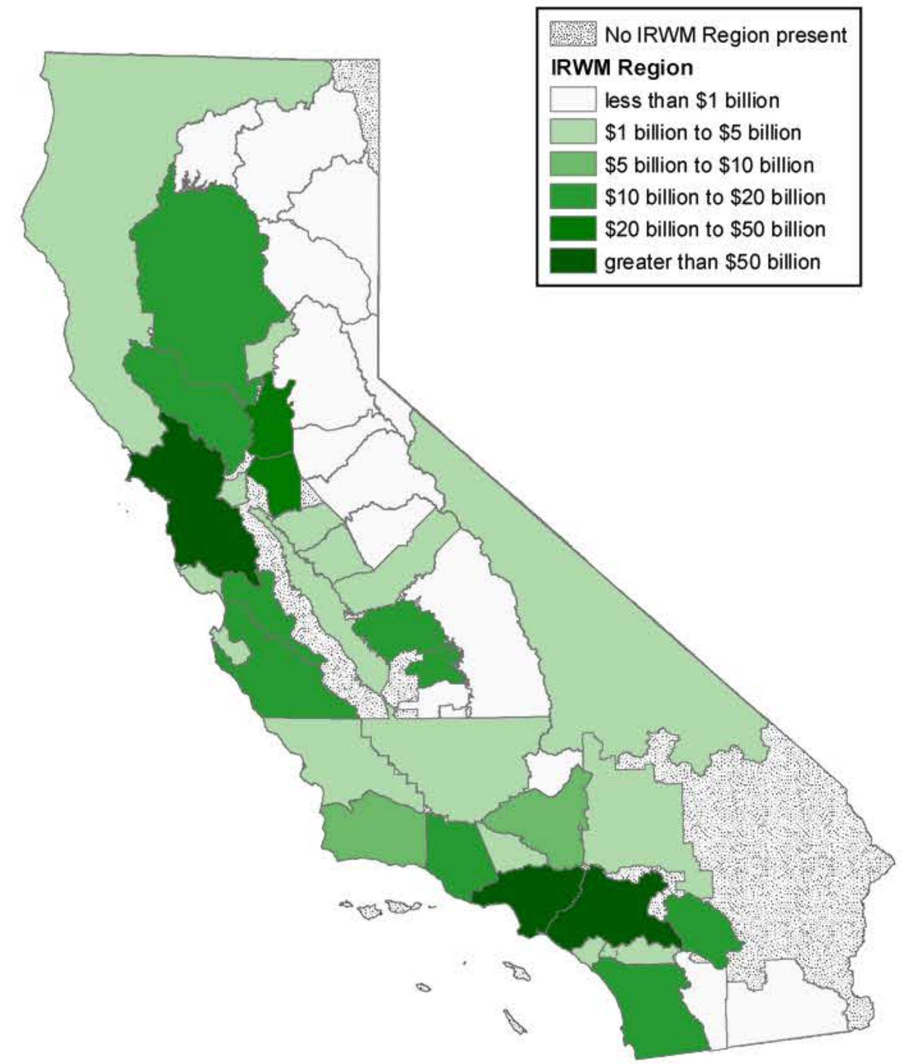
Population Exposed by IRWM Region



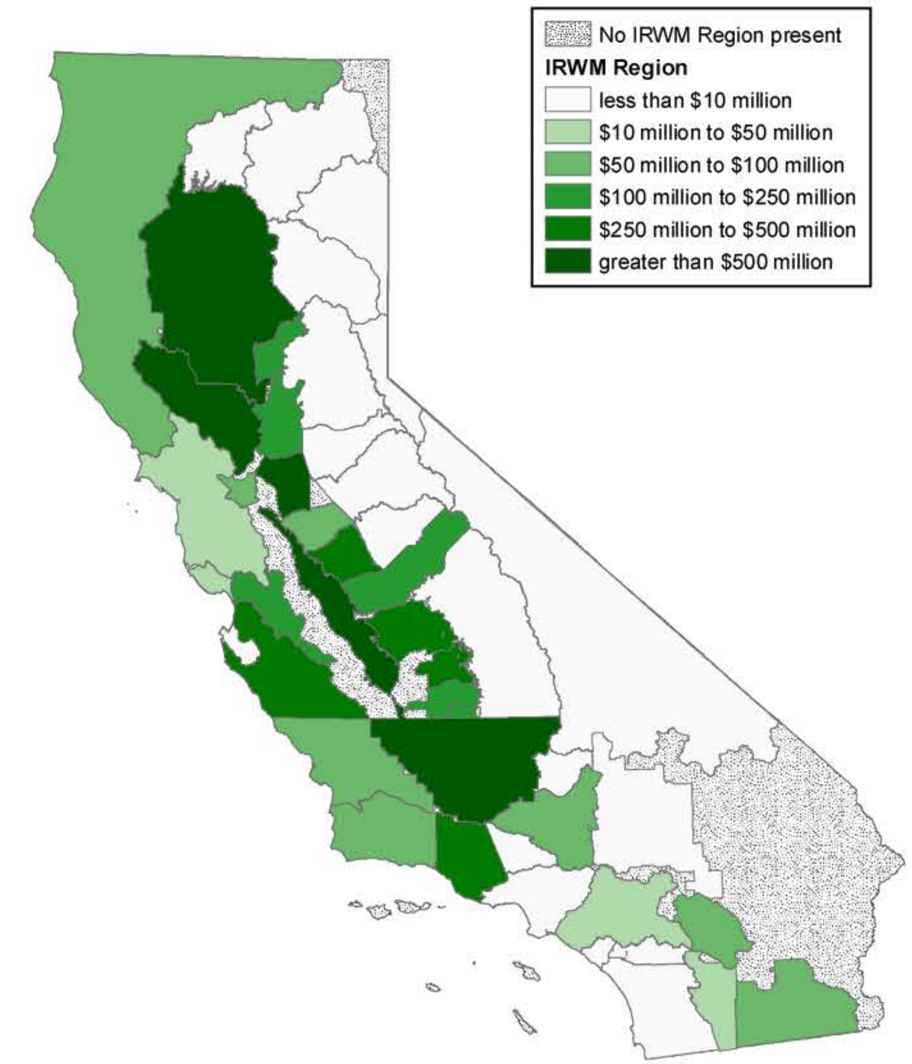
Total Population Exposed Statewide = 7.3 million

Value of Exposed Structures and Contents by IRWM Region



Total Value of Exposed Structures and Contents Statewide = $576.8 billion

Value of Exposed Agricultural Crops by IRWM Region



Total Value of Exposed Agricultural Crops = $7.5 billion

Figure F-22
Statewide Exposure to Flood Hazard, Reported by IRWM Region for a 500-year Flood Event

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Urban exposure to flood hazard for the 100-year floodplain is highly distributed across the IRWM regions. Twenty-nine IRWM regions each have more than 10,000 people exposed, and 25 IRWM regions each have more than $1 billion in structures and their contents exposed. Urban exposure to the 500-year floodplain is more concentrated than for the 100-year floodplain. Fifteen IRWM regions have exposed populations of more than 100,000 each, and 15 IRWM regions each have more than $10 billion in structures and their contents exposed in the 500-year floodplain. The Santa Ana Watershed Project Authority, Greater Los Angeles County, and San Francisco Bay area IRWM regions have the most exposure in population and in value of structures and contents in both the 100-year and 500-year floodplains.

Most of the exposure of agricultural crops to the 100-year floodplain occurs in the following 14 IRWM regions, each having more than $100 million in exposed agricultural crops:

- North Sacramento Valley Group
- Kern County
- Westside – San Joaquin
- Westside (Yolo, Solano, Napa, Lake, Colusa)
- Eastern San Joaquin
- Upper Kings Basin Water Forum
- Merced
- Greater Monterey County
- Madera
- Pajaro River Watershed
- Kaweah River Basin
- Watershed Coalition of Ventura County
- Poso Creek
- Tule

These IRWM regions make up more than 80 percent of the total value of exposed agricultural crops in the state. Exposure of agricultural crops to the 500-year floodplain is concentrated in 16 IRWM regions. The two additional IRWM regions are the American River Basin and Yuba County—each having more than $100 million in exposed agricultural crops. These IRWM regions also make up more than 80 percent of the total value of exposed agricultural crops in the state.

Exposure of sensitive plant species to flood hazard in the 100-year floodplain is distributed across the IRWM regions. Forty-five IRWM regions have more than 10 sensitive plant species in the 100-year floodplain, and five of those regions have more than 100 sensitive plant species. Forty-six IRWM regions have more than 10 sensitive plant species in the 500-year floodplain, and five of those regions have more than 100 sensitive plant species exposed in the 500-year floodplain.

Exposure of sensitive animal species to flood hazard is distributed across the IRWM regions. Forty-eight IRWM regions have more than 10 sensitive animal species, and two of those regions have more than 100 sensitive animal species exposed in both the 100-year and 500-year floodplains.

In both the 100-year and 500-year floodplains, about 9 percent of the exposed plant species were listed by the State of California as endangered, and about 10 percent of the exposed plant species were Federally listed as endangered. In both the 100-year and 500-year floodplains, about 2 percent of the exposed plant species were listed by the State of California as threatened, and about 4 percent of exposed plant species were Federally listed as threatened.

In both the 100-year and 500-year floodplains, about 8 percent of the exposed animal species were listed by the State of California as endangered, and about 12 percent of the exposed animal species were Federally listed as endangered. In both the 100-year and 500-year floodplains, about 6 percent of the exposed animal species were listed by the State of California as threatened, and about 5 percent of exposed animal species were Federally listed as threatened.

4.1.4 CWP Hydrologic Regions and Delta Zones

CWP Hydrologic Region Results

Population and Value of Structures and Contents

South Coast and San Francisco Bay regions have the most exposure to 100-year and 500-year floodplains.

South Coast exposure to 500-year floodplain totals more than 3.4 million people and $230 billion in value of structures and contents.

Agricultural Crop Values

Sacramento River, San Joaquin River, and Tulare Lake regions have the most exposure to 100-year and 500-year floodplains.

Population, Structures and Agricultural Crops

Tables F-9, F-10, and F-11 and Figures F-23 and F-24 show the exposure results for the 10 CWP hydrologic regions, 2 overlay regions, and 2 Delta zones in population, value of structures and their contents, and value of agricultural crops in the 100-year and 500-year floodplains. The figures are in the same format as those for the other regions. In addition, Figures F-25 and F-26 depict the percent exposed in each region for each category. Finally, Figures F-27 and F-28 depict the approximate results for each of the 10 CWP hydrologic regions for the 100-year and 500-year floodplains.

Exposure to flood hazard is distributed throughout the state with all of the CWP hydrologic and overlay regions and Delta zones having some level of exposure to flooding. The San Francisco Bay and South Coast regions have the highest levels of exposure, with more than 250,000 people within the 100-year floodplain and more than 1 million people within the 500-year floodplain in each region. The highest percent exposure levels are in the Sacramento River, San Joaquin River, and Tulare Lake regions for the 100-year floodplain and in the Sacramento River, San Joaquin River, and Colorado River regions for the 500-year floodplain.

The San Francisco Bay and South Coast regions have the greatest exposure to flood hazard in terms of population and in terms of value of structures and their contents for both the 100-year and 500-year floodplains. The exposed values are comparable between the two regions for the 100-year floodplain, but the South Coast has the greater exposure in population and value of structures and contents within the 500-year floodplain. The South Coast exposure to the 500-year floodplain totals more than 3.4 million people and more than $230 billion in structures and contents. The San Francisco Bay region exposure to the 500-year floodplain is smaller but still significant, with more than 1 million people and more than $130 billion in structures and contents.

Table F-9. Summary of Population Exposure Results by Analysis Region Category

Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than 30,000	No. Greater Than 100,000	No. Greater Than 250,000	No. Greater Than 500,000	No. Greater Than 1,000,000	No. Greater Than 30,000	No. Greater Than 100,000	No. Greater Than 250,000	No. Greater Than 500,000	No. Greater Than 1,000,000
CWP Hydrologic Regions	10	8	5	2	0	0	9	8	6	4	2
CWP Overlay Regions	2	1	0	0	0	0	1	1	0	0	0
Delta Zones	2	1	0	0	0	0	1	1	0	0	0

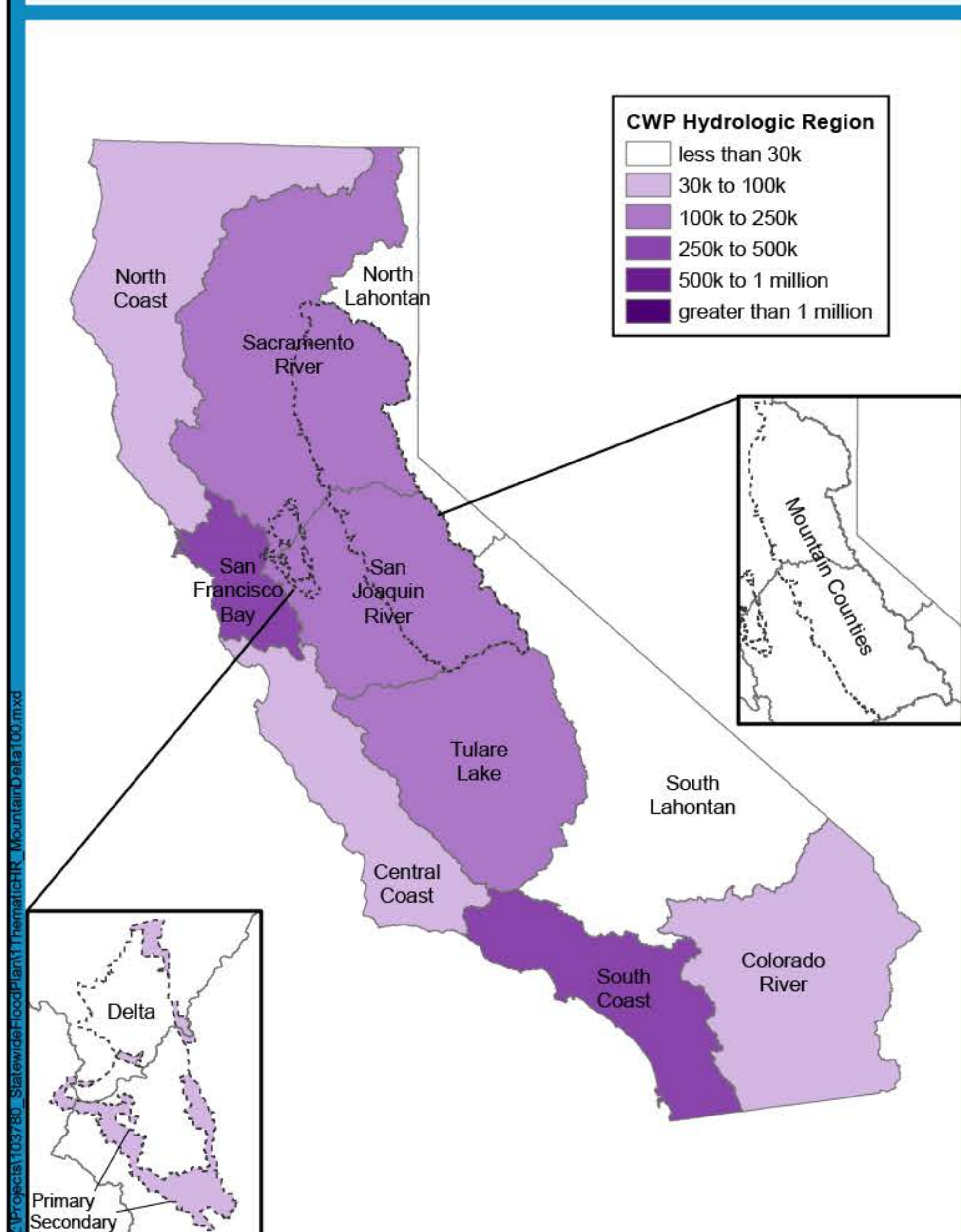
Table F-10. Summary of Structures and Contents Exposure Results by Analysis Region Category

Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than $5 Billion	No. Greater Than $15 Billion	No. Greater Than $30 Billion	No. Greater Than $50 Billion	No. Greater Than $80 Billion	No. Greater Than $5 Billion	No. Greater Than $15 Billion	No. Greater Than $30 Billion	No. Greater Than $50 Billion	No. Greater Than $80 Billion
CWP Hydrologic Regions	10	6	3	2	0	0	8	7	6	3	2
CWP Overlay Regions	2	1	0	0	0	0	1	1	0	0	0
Delta Zones	2	1	0	0	0	0	1	1	0	0	0

Table F-11. Summary of Agricultural Crops Exposure Results by Analysis Region Category

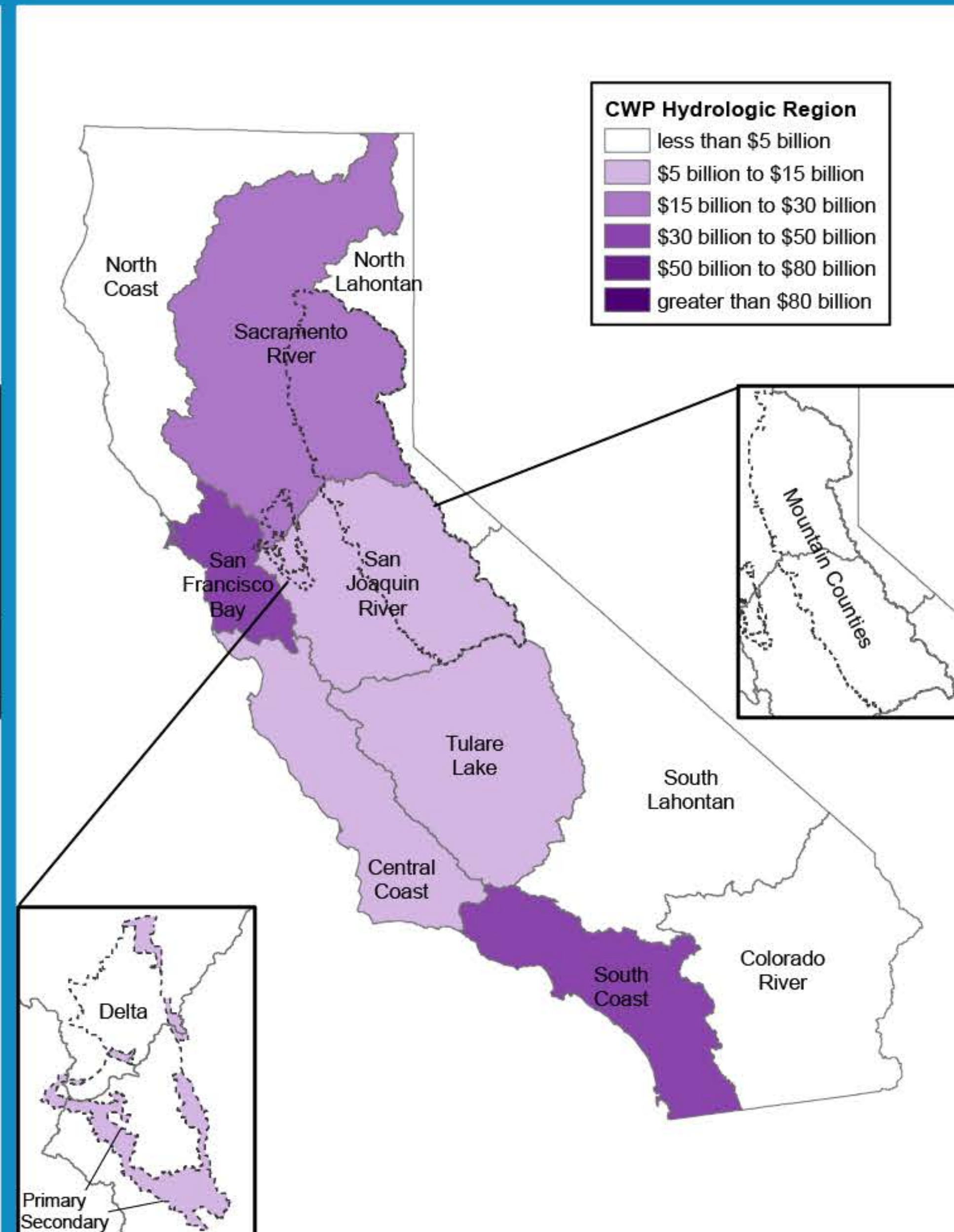
Analysis Region Category	No. of Regions	100-year Floodplain Results					500-year Floodplain Results				
		No. Greater Than $100 million	No. Greater Than $250 million	No. Greater Than $500 million	No. Greater Than $1 Billion	No. Greater Than $2 Billion	No. Greater Than $100 million	No. Greater Than $250 million	No. Greater Than $500 million	No. Greater Than $1 Billion	No. Greater Than $2 Billion
CWP Hydrologic Regions	10	6	4	4	3	0	6	6	4	3	1
CWP Overlay Regions	2	1	1	1	0	0	1	1	1	1	0
Delta Zones	2	1	1	1	0	0	2	1	1	0	0

Population Exposed by CWP Hydrologic Region and Delta Zone



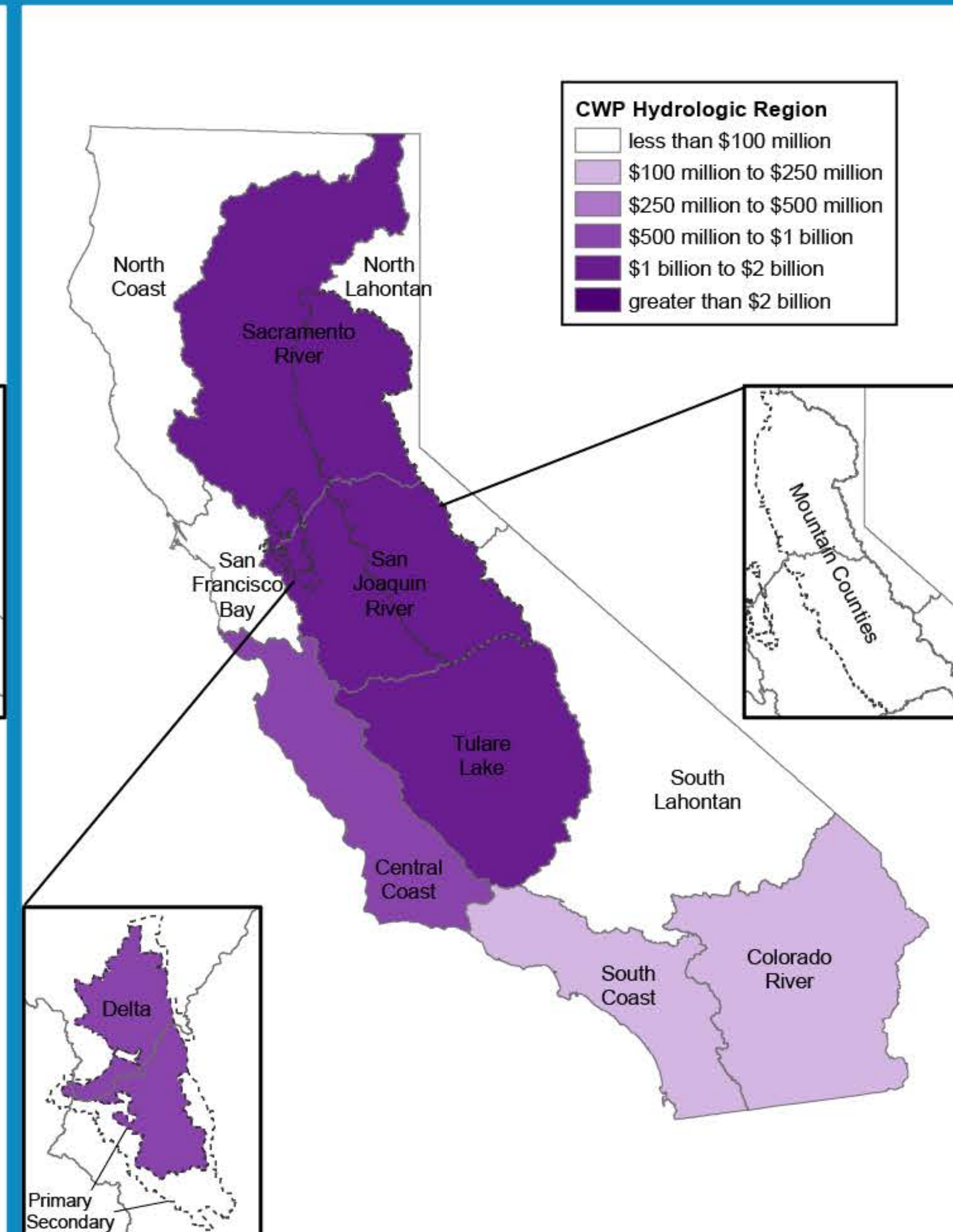
Total Population Exposed Statewide = 1.4 million (4%)

Value of Exposed Structures and Contents by CWP Hydrologic Region and Delta Zone



Total Value of Exposed Structures and Contents Statewide = $136.7 billion (5%)

Value of Exposed Agricultural Crops by CWP Hydrologic Region and Delta Zone



Total Value of Exposed Agricultural Crops = $5.4 billion (27%)

Figure F-23
Statewide Exposure to Flood Hazard, Reported by CWP Hydrologic Region and Delta Zone for a 100-year Flood Event

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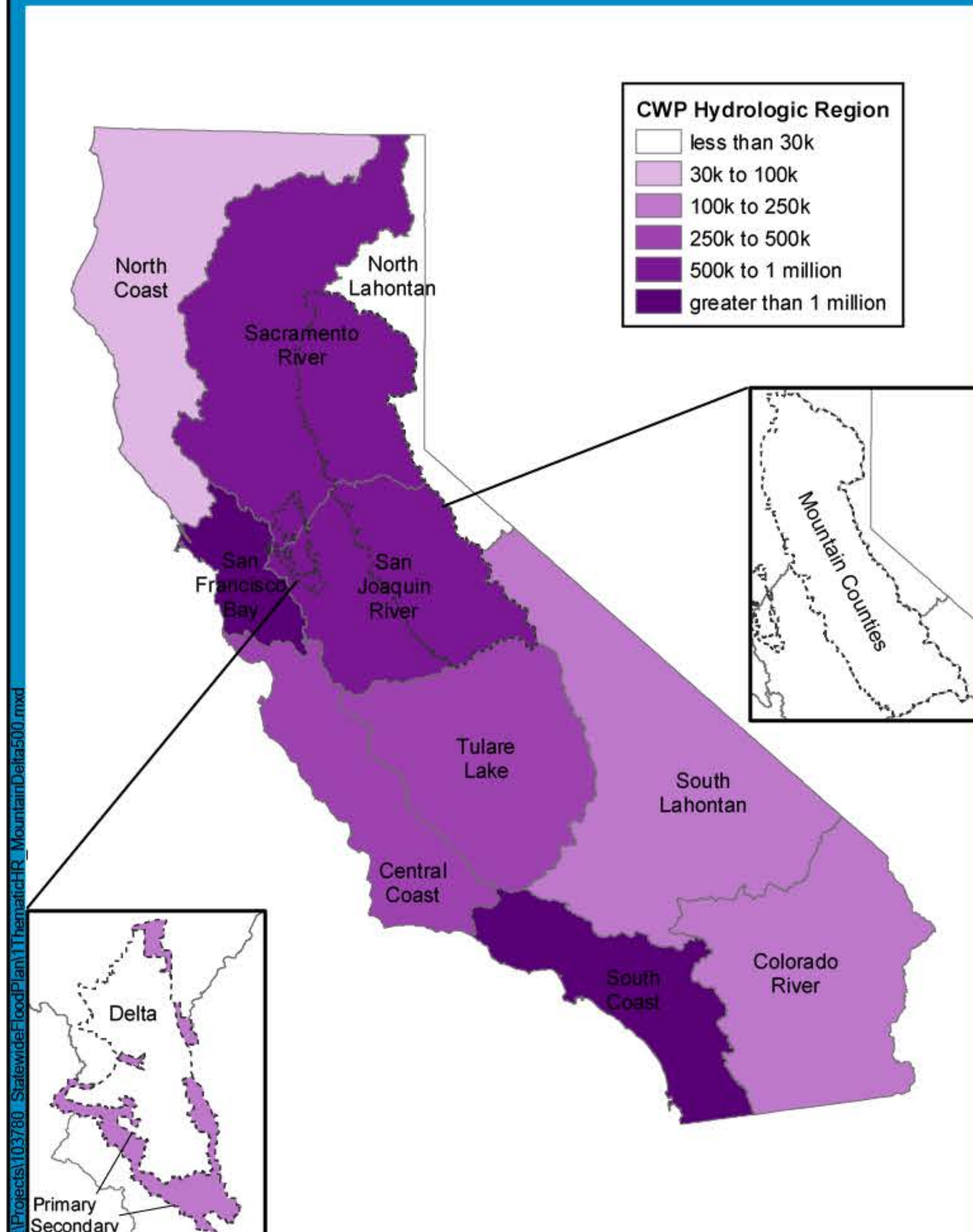
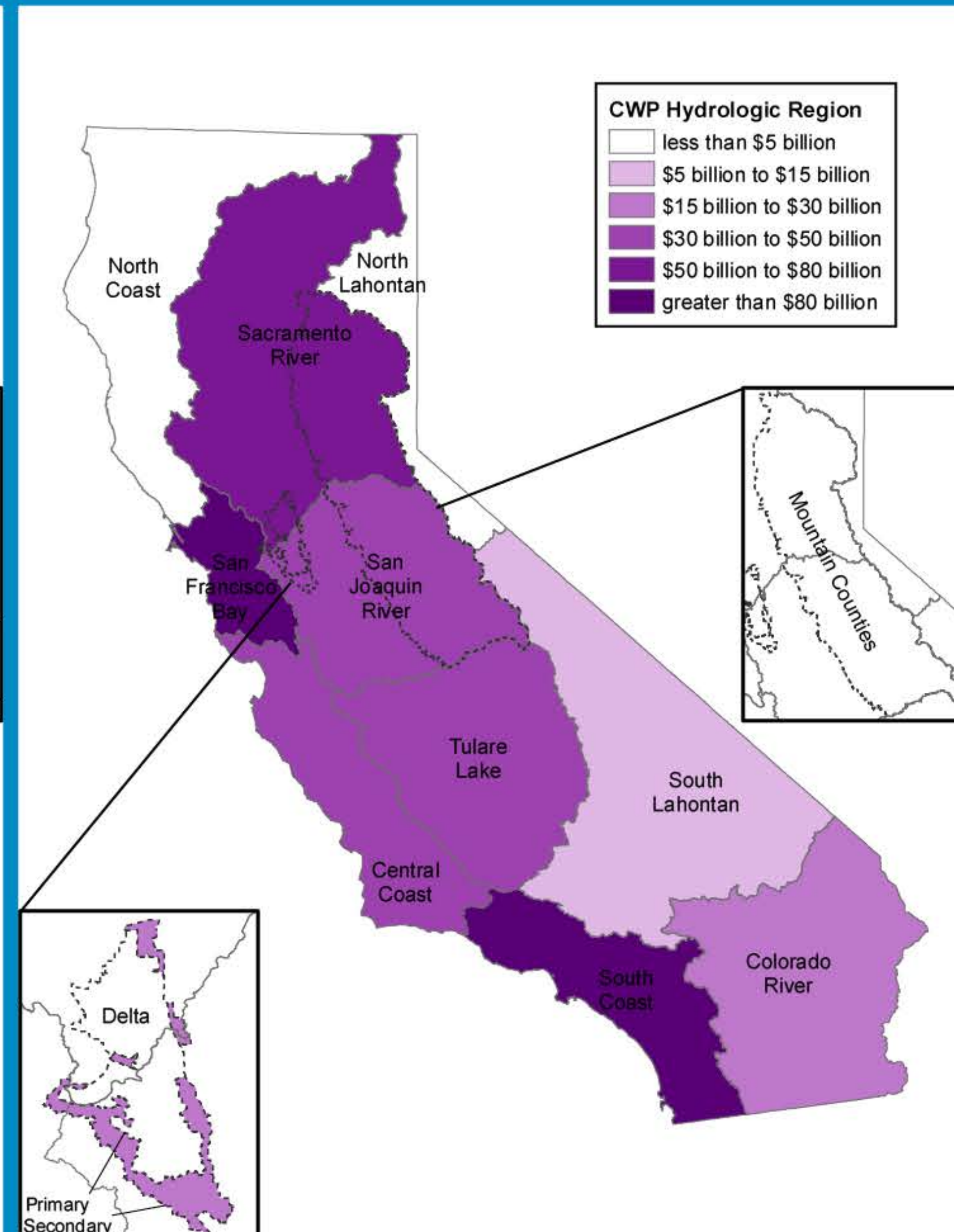
Population Exposed by CWP Hydrologic Region and Delta Zone



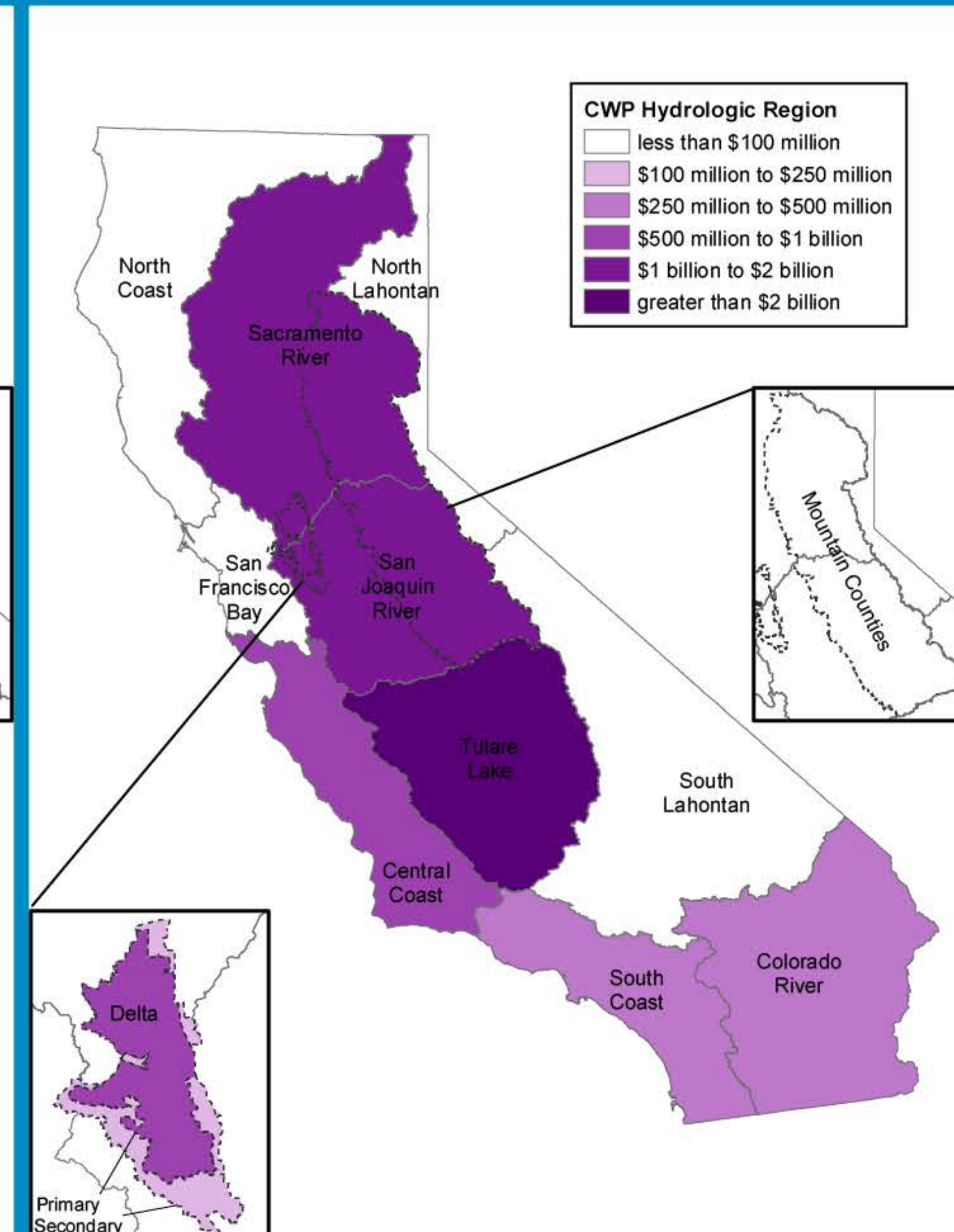
Total Population Exposed Statewide = 7.3 million (21%)

Value of Exposed Structures and Contents by CWP Hydrologic Region and Delta Zone



Total Value of Exposed Structures and Contents Statewide = $576.8 billion (20%)

Value of Exposed Agricultural Crops by CWP Hydrologic Region and Delta Zone



Total Value of Exposed Agricultural Crops = $7.5 billion (35%)

Figure F-24
Statewide Exposure to Flood Hazard, Reported by CWP Hydrologic Region and Delta Zone for a 500-year Flood Event

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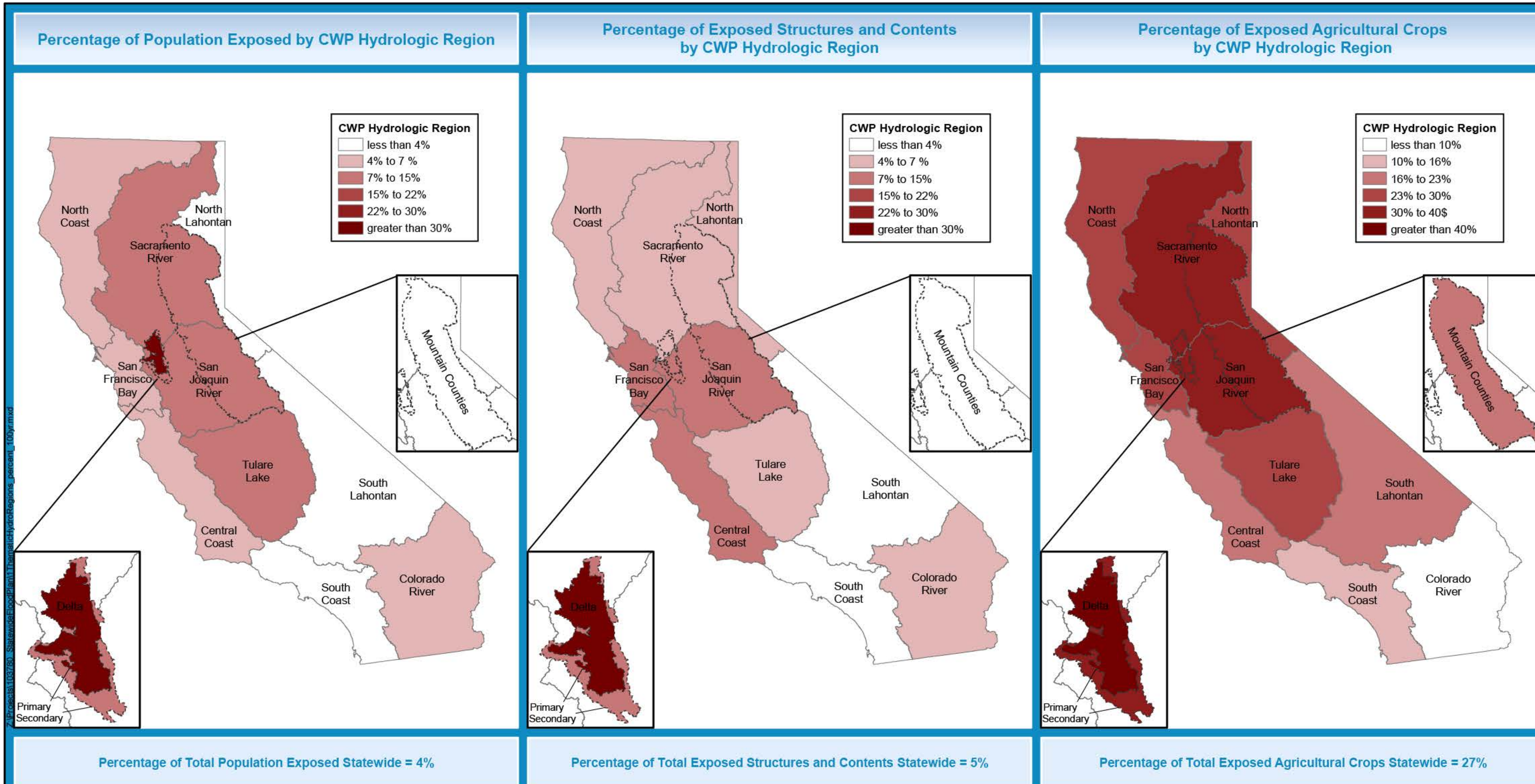

Figure F-25
Percentage of Statewide Exposure to Flood Hazard, Reported by CWP Hydrologic Region and Delta Zone for a 100-year Flood Event

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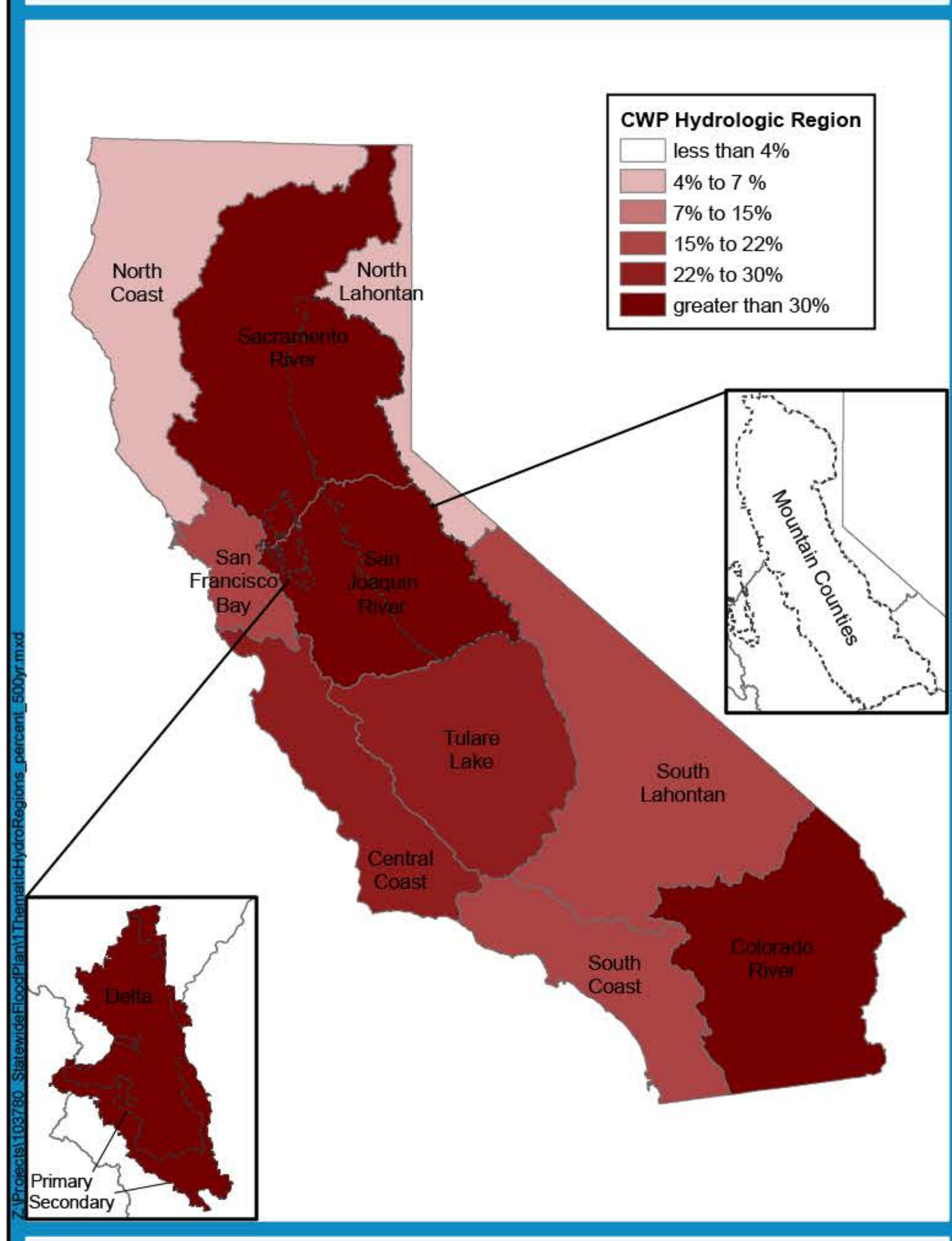
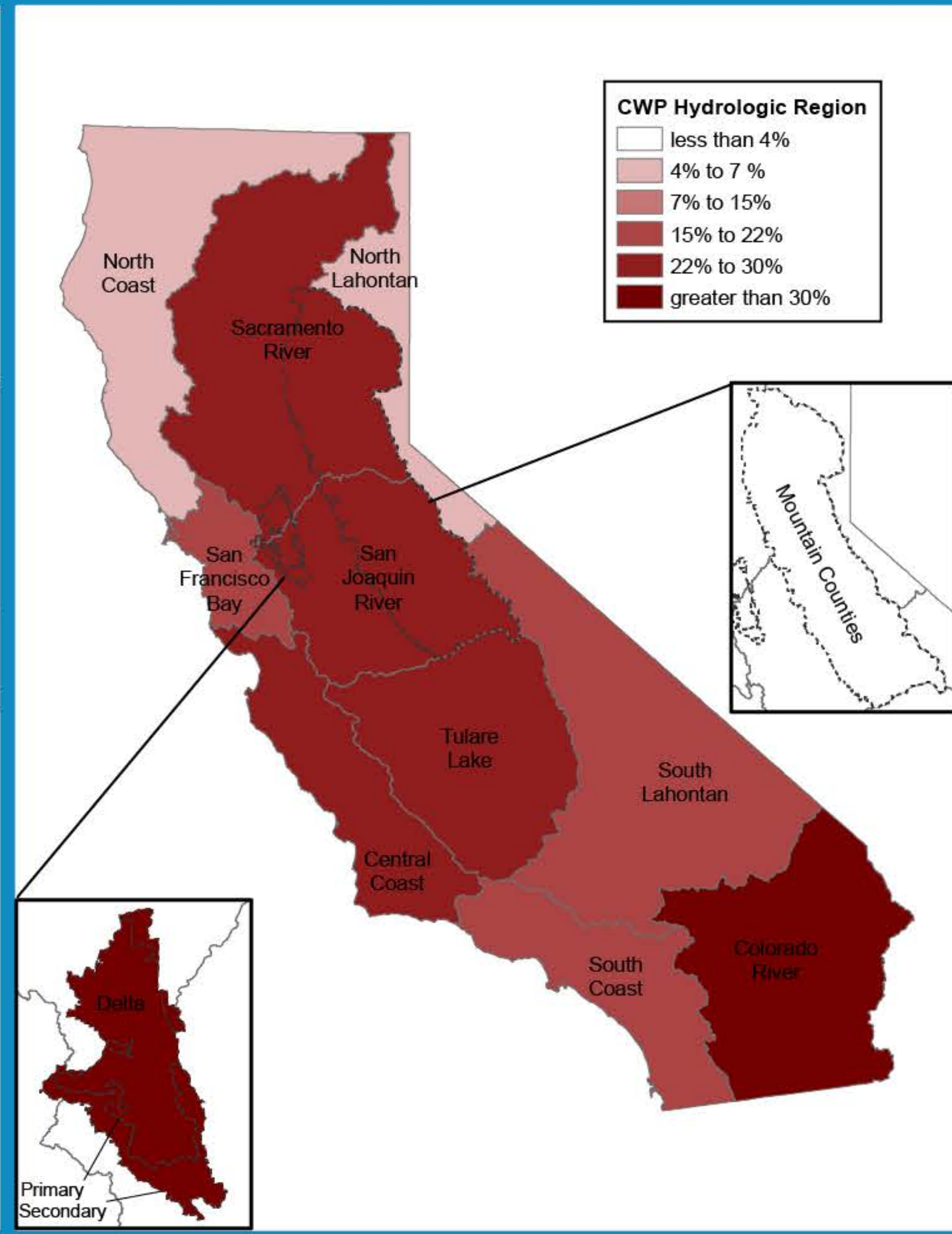
Percentage of Population Exposed by CWP Hydrologic Region



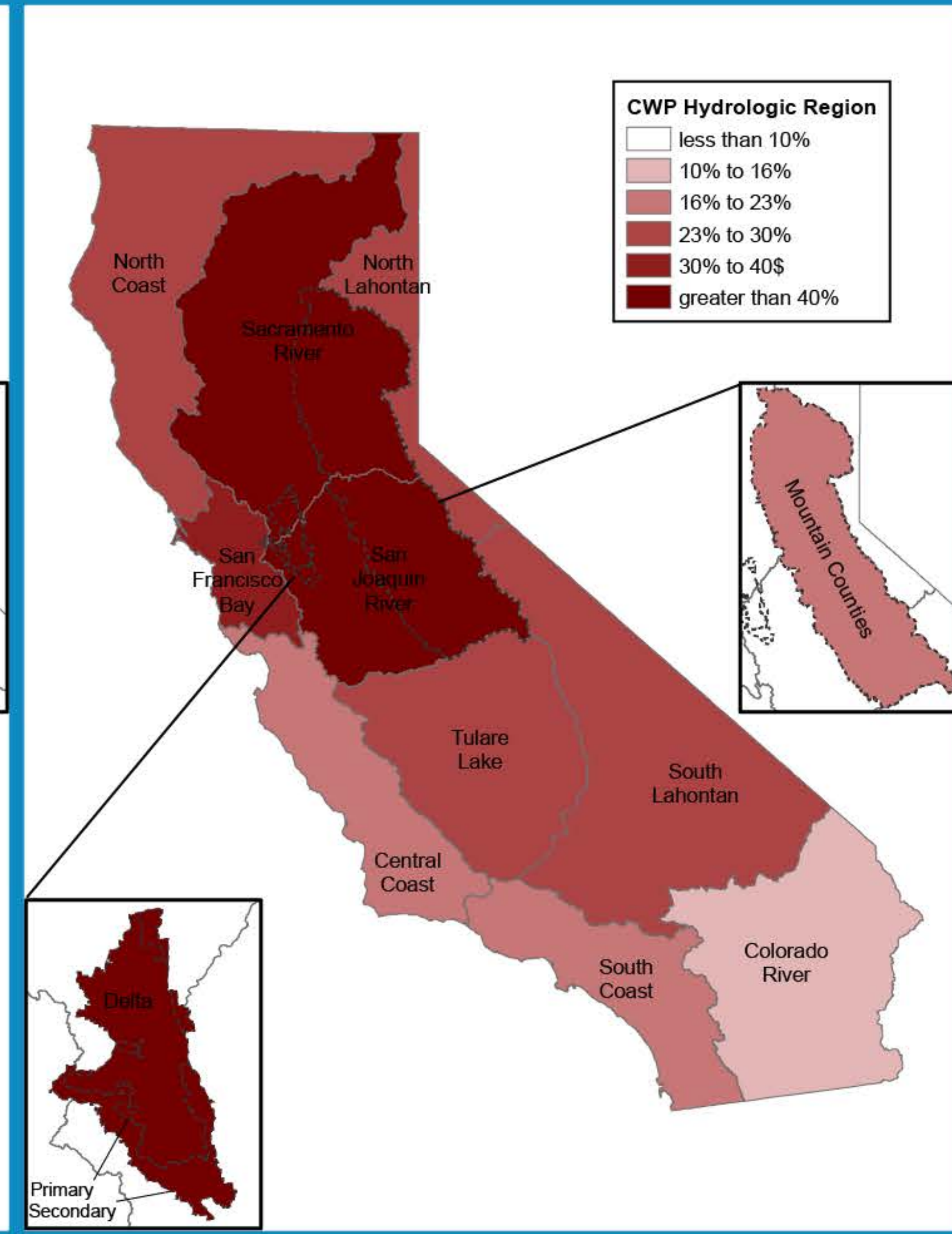
Percentage of Total Population Exposed Statewide = 21%

Percentage of Exposed Structures and Contents by CWP Hydrologic Region



Percentage of Total Exposed Structures and Contents Statewide = 20%

Percentage of Exposed Agricultural Crops by CWP Hydrologic Region



Percentage of Total Exposed Agricultural Crops Statewide = 35%

Figure F-26
Percentage of Statewide Exposure to Flood Hazard, Reported by CWP Hydrologic Region and Delta Zone for a 500-year Flood Event

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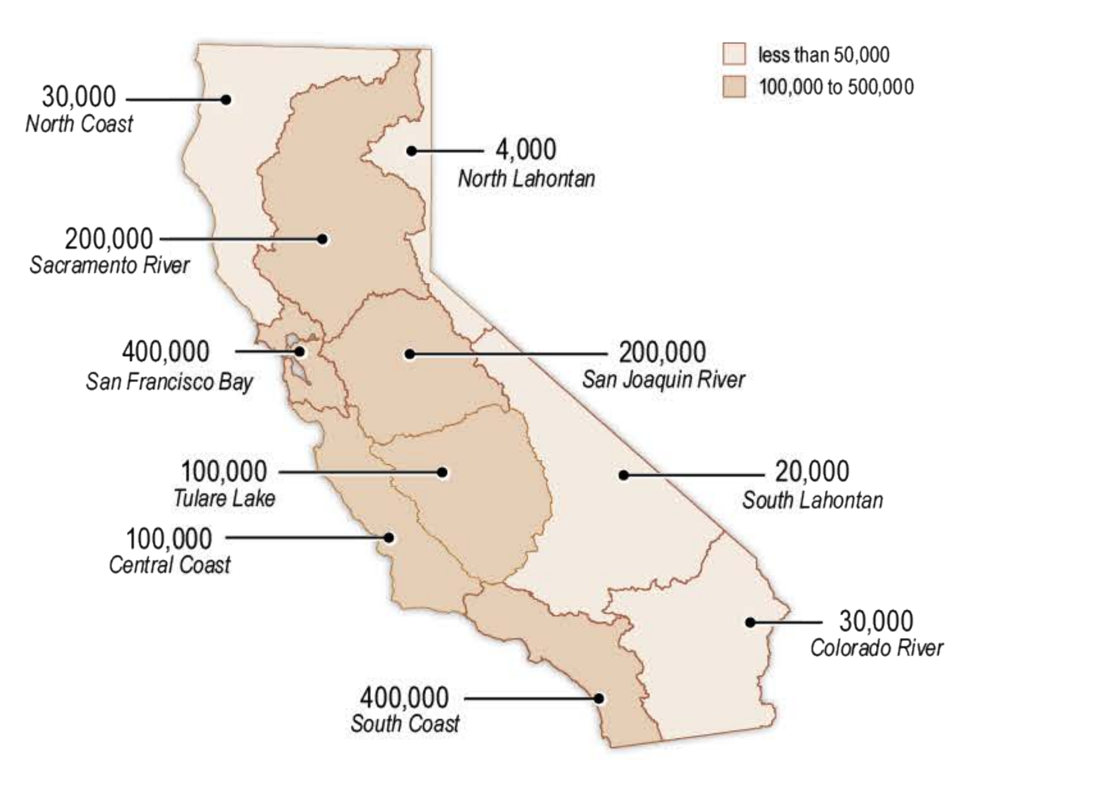
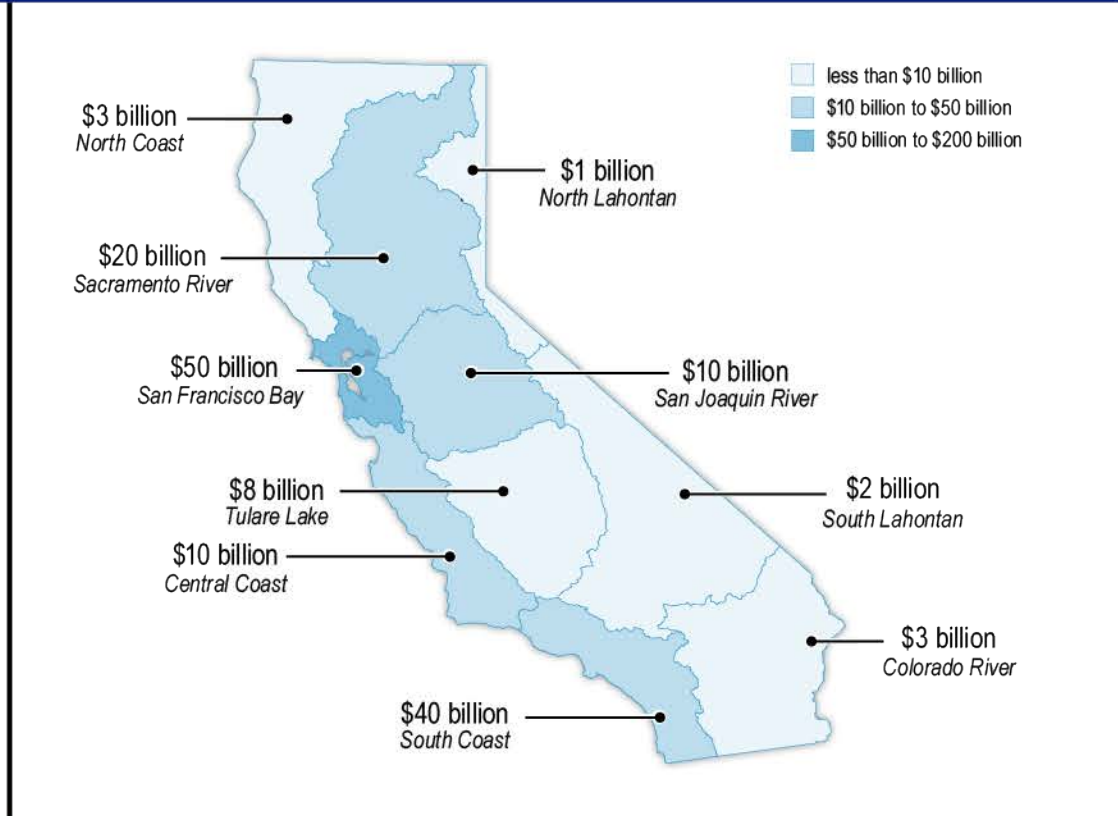
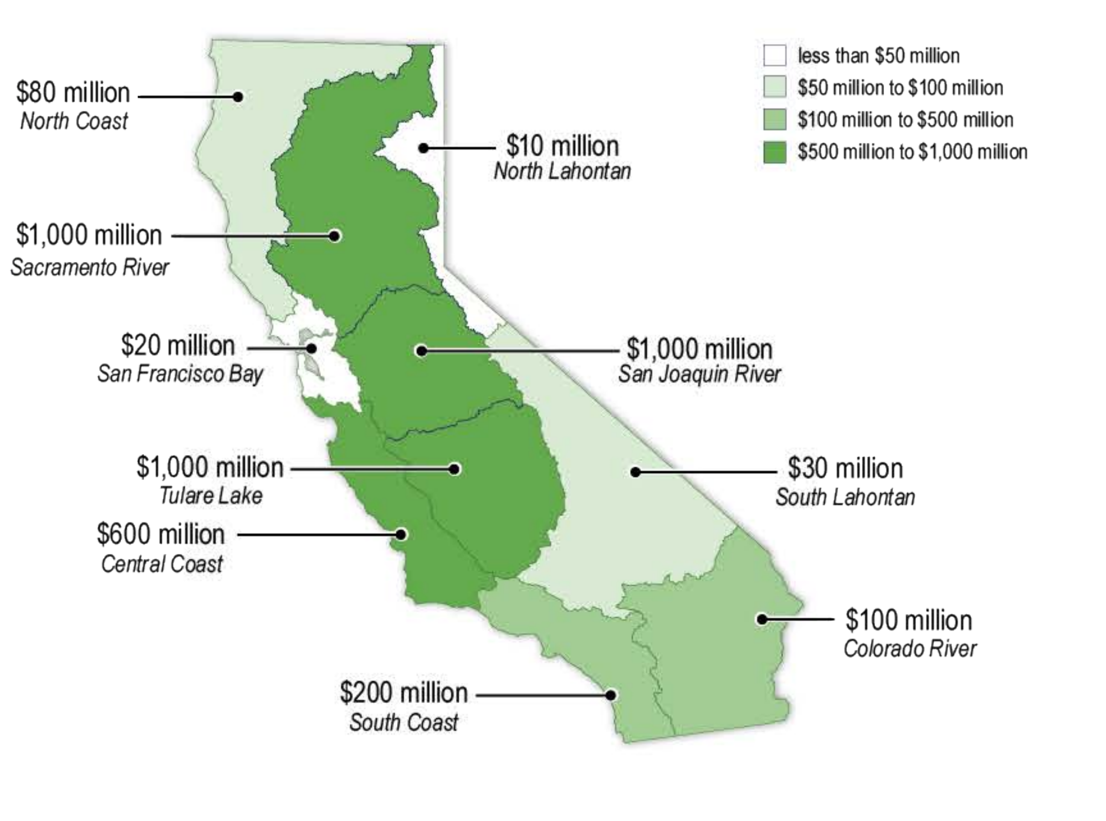


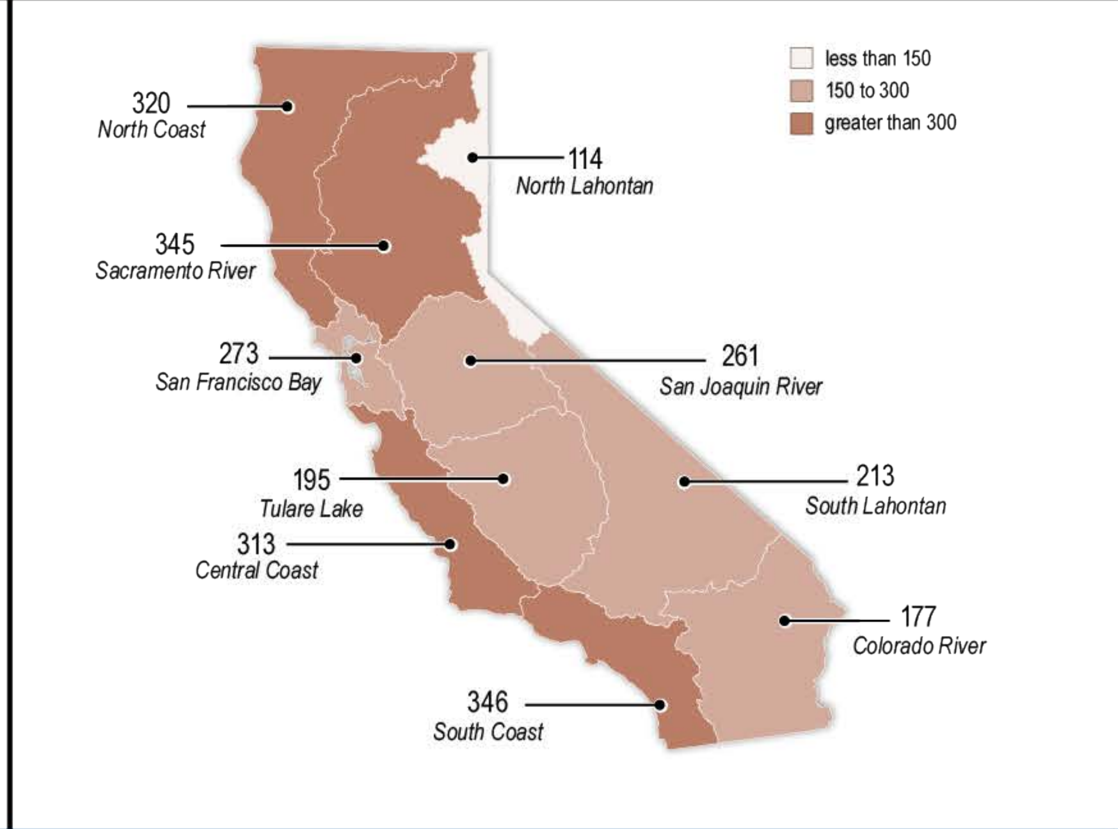
Population Exposed by CWP Hydrologic Region



Value of Exposed Structures and Contents by CWP Hydrologic Region



Value of Exposed Agricultural Crops by CWP Hydrologic Region



Total Species (Plant and Animal) Exposed by CWP Hydrologic Region

Figure F-27

Exposure of Population, Structures, and Contents Value, Agricultural Crops Value, and Sensitive Species to 100-Year Floodplain

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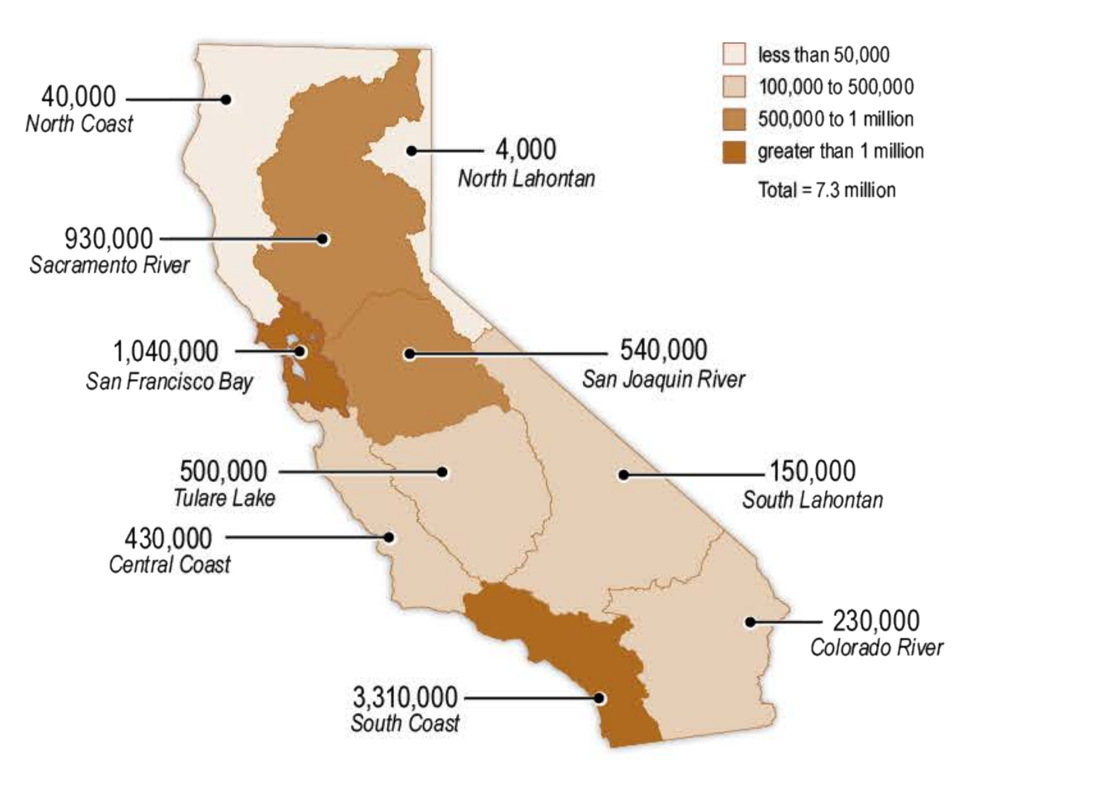
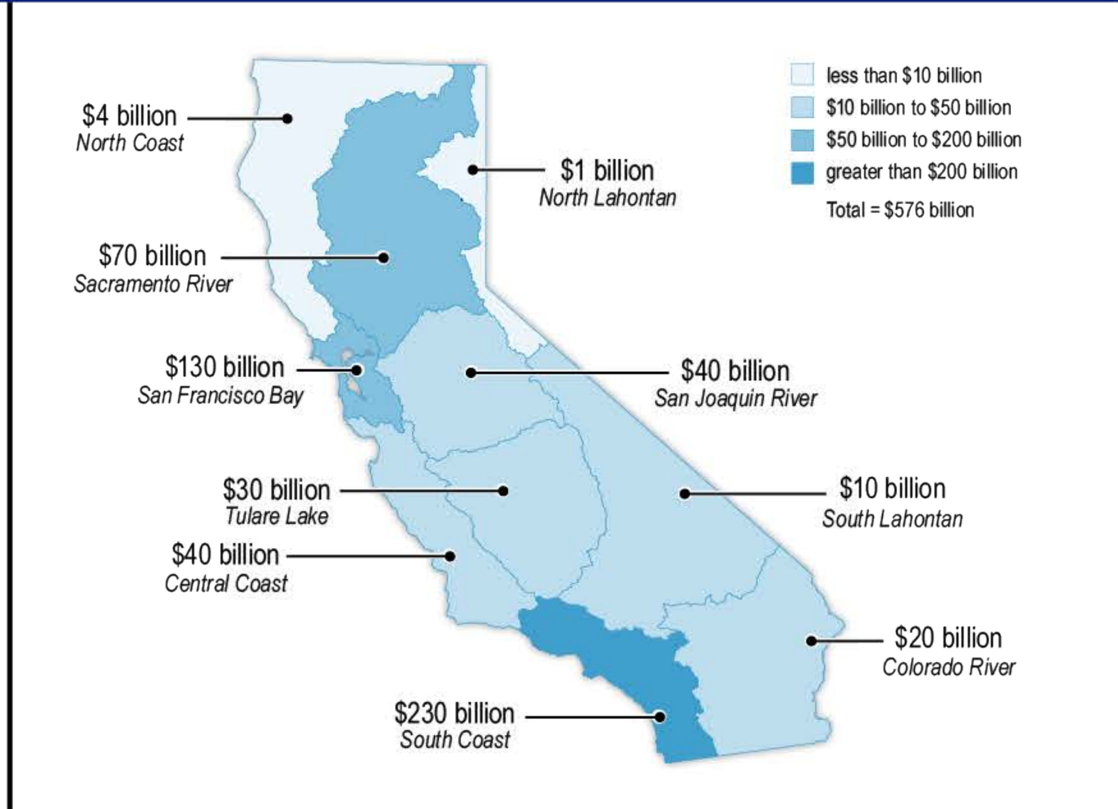
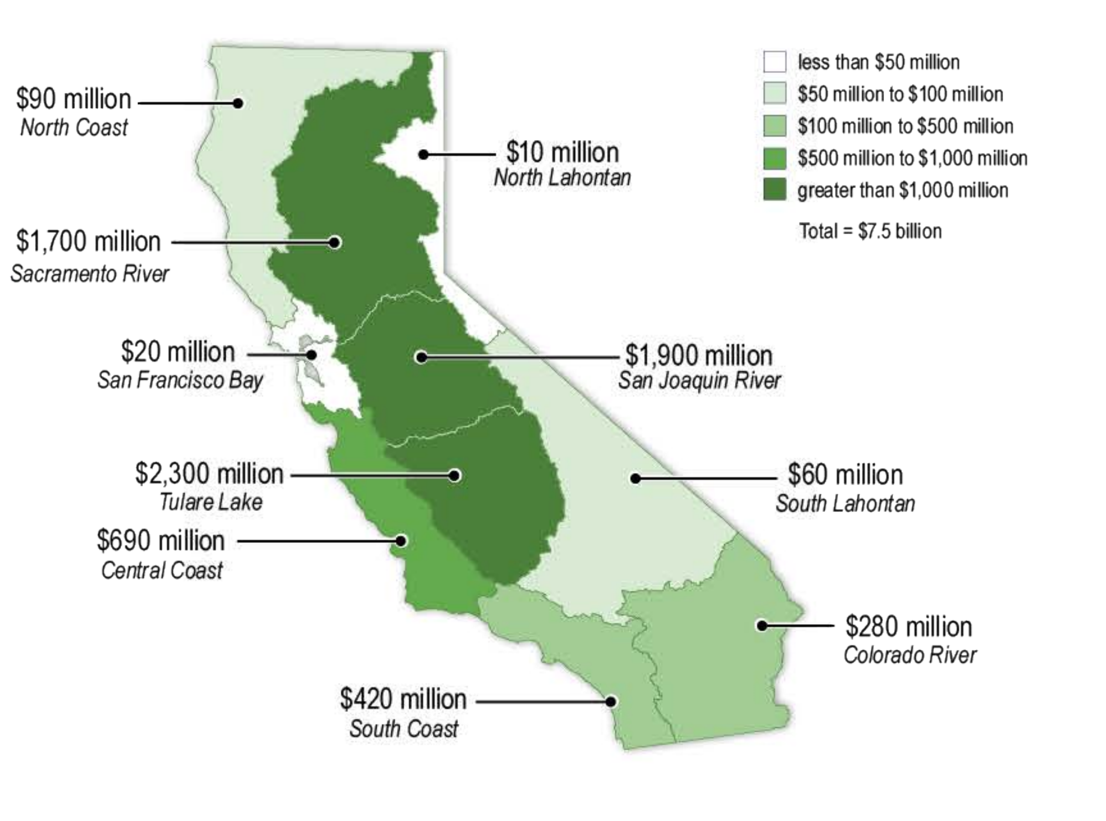


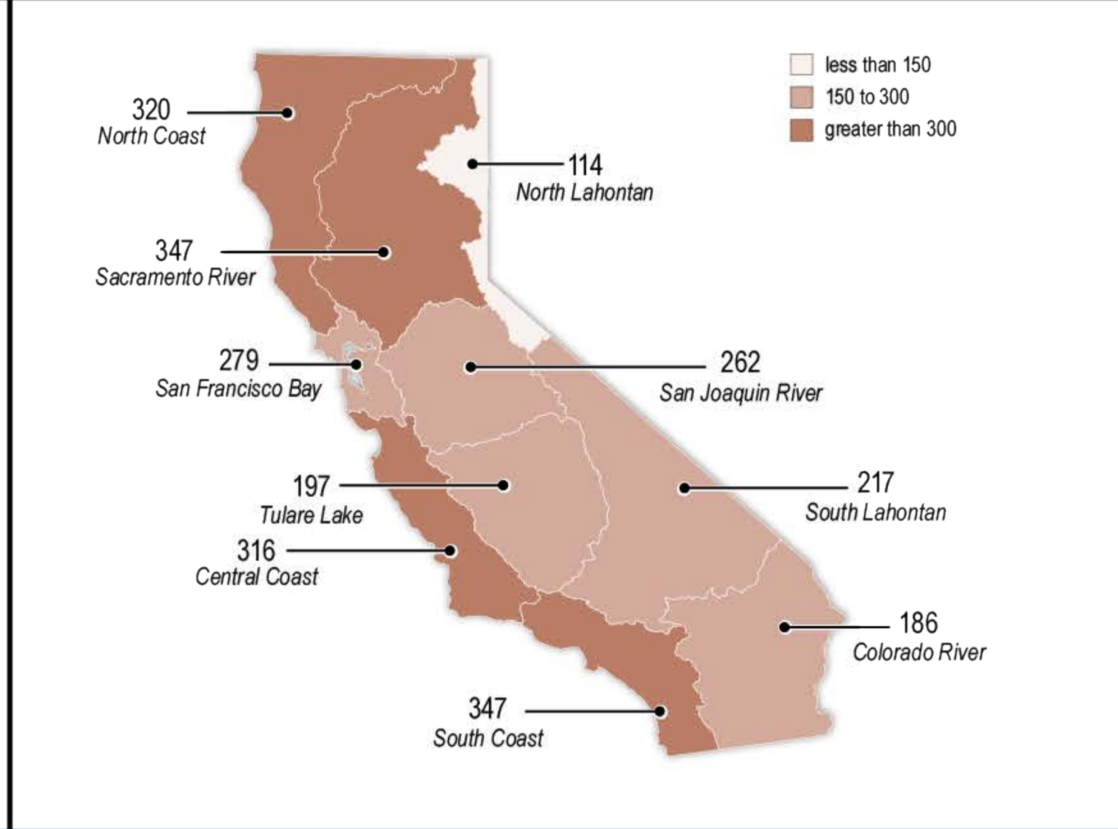
Population Exposed by CWP Hydrologic Region



Value of Exposed Structures and Contents by CWP Hydrologic Region



Value of Exposed Agricultural Crops by CWP Hydrologic Region



Total Species (Plant and Animal) Exposed by CWP Hydrologic Region

Figure F-28

Exposure of Population, Structures, and Contents Value, Agricultural Crops Value, and Sensitive Species to 500-Year Floodplain

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The Sacramento River, San Joaquin River, and Tulare Lake regions have the greatest exposure in terms of agricultural crop values, with more than $1 billion in agricultural crops exposed in each region for both the 100-year and the 500-year floodplains. The Tulare Lake region has the greatest exposure of agricultural crop value, with more than $2 billion exposed for the 500-year floodplain. The Sacramento River and San Joaquin River regions have the largest percentage of agricultural acreage exposed in both the 100-year and 500-year floodplains.

CNDDB Sensitive Plant and Animal Species

Exposure of sensitive plant and animal species to flood hazard is distributed throughout the state, with all CWP hydrologic regions, overlay regions, and Delta zones having some level of exposure to flooding. Figures F-27 and F-28 present the total number of sensitive species exposed to the 100-year and 500-year floodplains. The South Coast, North Coast, Sacramento River, and Central Coast hydrologic regions have the highest levels of exposure for sensitive plant species, with more than 200 sensitive plant species in both the 100-year and 500-year floodplains of each region. The Sacramento River, South Coast, and San Joaquin River hydrologic regions have the highest levels of exposure for sensitive animal species, with more than 125 sensitive animal species in both the 100-year and 500-year floodplains of each region.

Table F-12 shows the number of sensitive plant and animal species exposed in each CWP hydrologic region. The South Coast Hydrologic Region has the largest number of sensitive plant species exposed in both the 100-year and 500-year floodplains, and the Sacramento River Hydrologic Region has the largest number of sensitive animal species exposed in both the 100-year and 500-year floodplains.

Table F-12. Exposed Sensitive Plant and Animal Species in Each Hydrologic Region

CWP Hydrologic Region	Exposed Sensitive Plant and Animal Species from CNDDB			
	100-Year Floodplain		500-Year Floodplain	
	Sensitive Plant Species	Sensitive Animal Species	Sensitive Plant Species	Sensitive Animal Species
Central Coast	202	111	204	112
Colorado River	78	99	85	101
North Coast	203	117	203	117
North Lahontan	68	46	68	46
Sacramento River	203	142	205	142
San Francisco Bay	167	106	169	110
San Joaquin River	130	131	131	131
South Coast	210	136	210	137
South Lahontan	100	113	104	113
Tulare Lake	94	101	94	103
Overlay Regions				
Sacramento-San Joaquin Delta	46	61	46	64
Mountain Counties	123	87	123	87

Critical Facilities

Figures F-29 and F-30 present the numbers of critical facilities exposed to the 100-year and 500-year floodplains. The South Coast, San Francisco Bay, and Sacramento River regions have the most essential, high potential loss, and lifeline facilities exposed to both the 100-year and 500-year floodplains. Although the total numbers are relatively similar for the 100-year floodplain, the South Coast region has far more exposure of these types of facilities in the 500-year floodplain, with more than 40 percent of the state's exposed essential, high potential loss, and lifeline facilities being in the South Coast region.

Exposure of transportation facilities occurs in many parts of the state, with the South Coast, San Francisco Bay, Sacramento River, San Joaquin River, Tulare Lake, and Central Coast regions having large numbers of exposed transportation facilities in both the 100-year and 500-year floodplains.

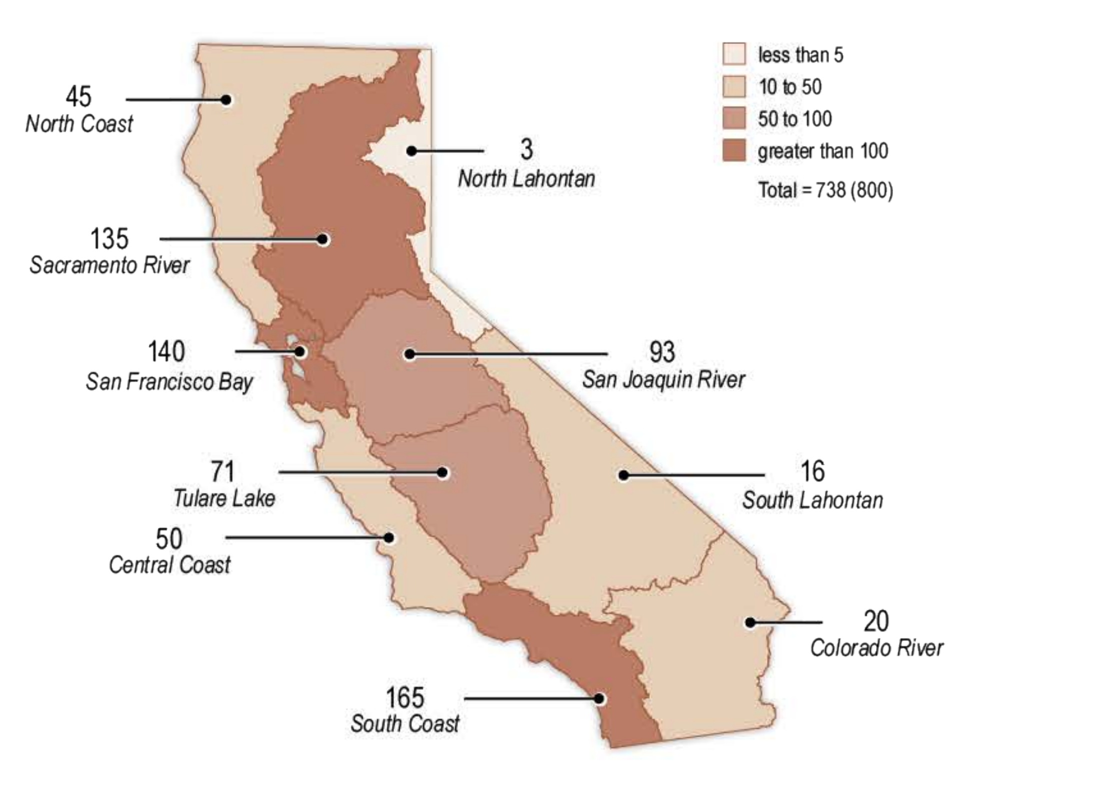
Department of Defense Facilities

Table F-13 shows the number and acreage of exposed DoD facilities in each CWP hydrologic region. The South Coast Hydrologic Region has the largest number of exposed DoD facilities in both the 100-year and 500-year floodplains.

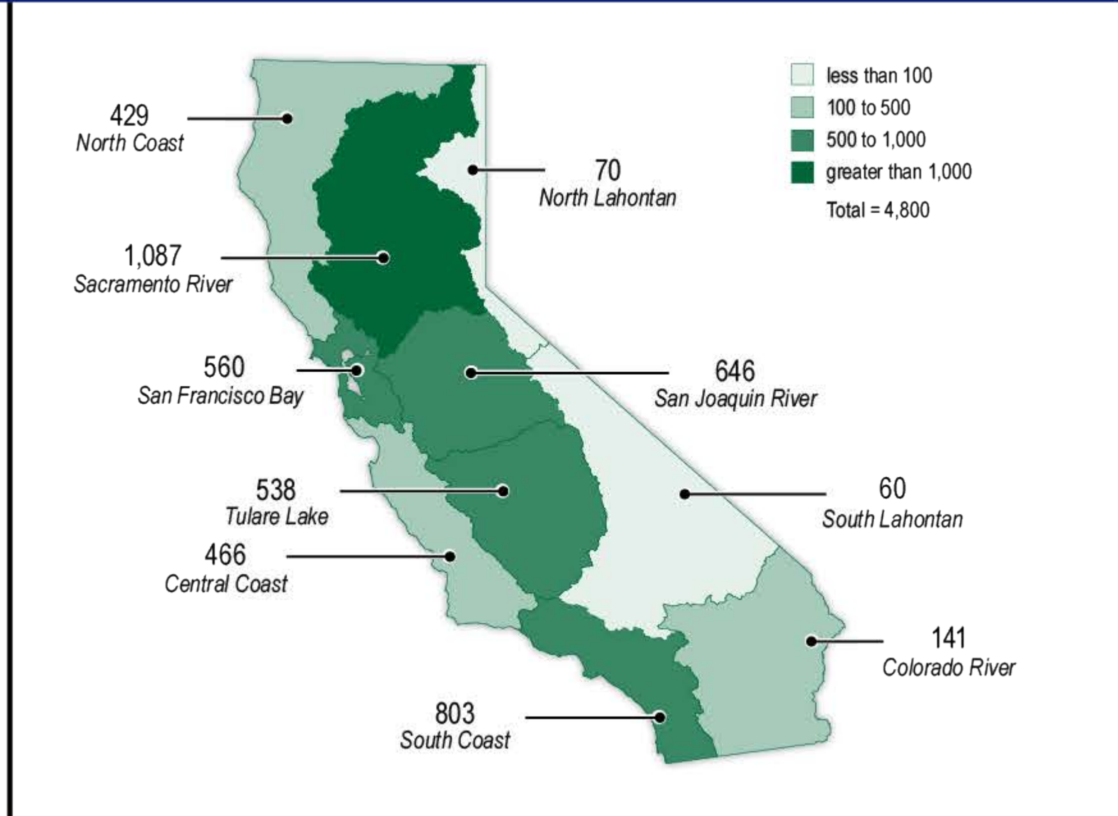
Table F-13. Exposed Department of Defense Facilities in Each Hydrologic Region

CWP Hydrologic Region	Exposed Department of Defense Facilities			
	100-Year Floodplain		500-Year Floodplain	
	Number	Acres	Number	Acres
Central Coast	5	13,480	5	15,332
Colorado River	4	16,962	4	16,963
North Coast	0	0	0	-
North Lahontan	1	56,674	1	56,674
Sacramento River	5	4,970	6	5,841
San Francisco Bay	8	2,813	8	2,914
San Joaquin River	2	597	2	831
South Coast	16	1,252	16	4,337
South Lahontan	4	6,498	4	9,377
Tulare Lake	7	25,143	7	25,396
Overlay Regions				
Sacramento-San Joaquin Delta	2	34	2	52
Mountain Counties	0	0	0	0

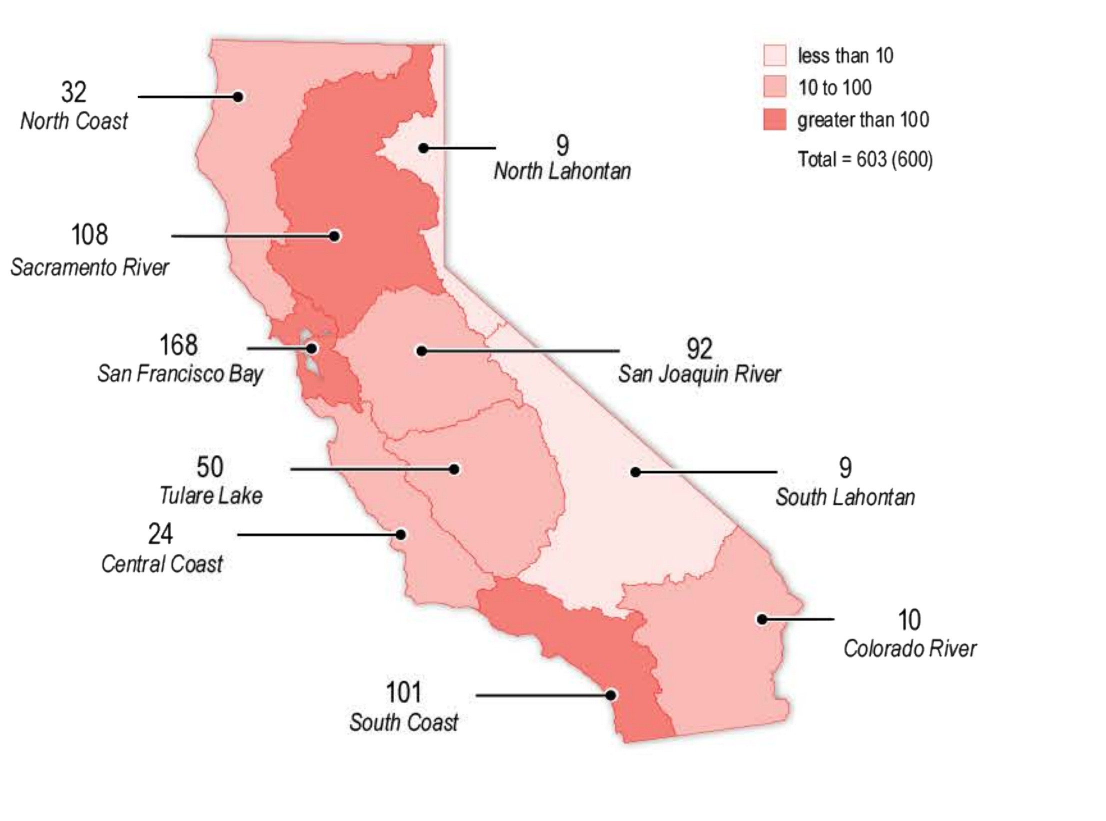
Note: Acres numbers are rounded to the nearest hundred.



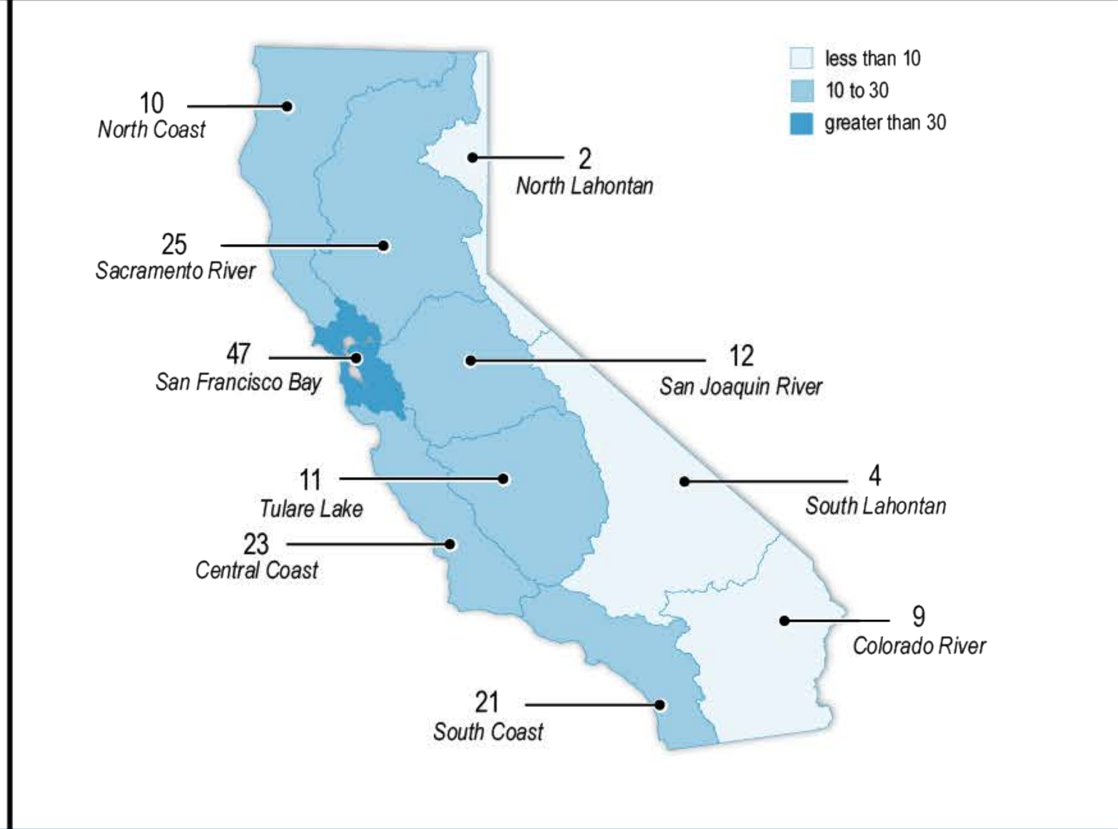
Essential Facilities Exposed by CWP Hydrologic Region



Transportation Facilities Exposed by CWP Hydrologic Region



High Potential Facilities Exposed by CWP Hydrologic Region



Lifeline Utilities Exposed by CWP Hydrologic Region

Figure F-29
Facilities Exposure to
100-Year Floodplain

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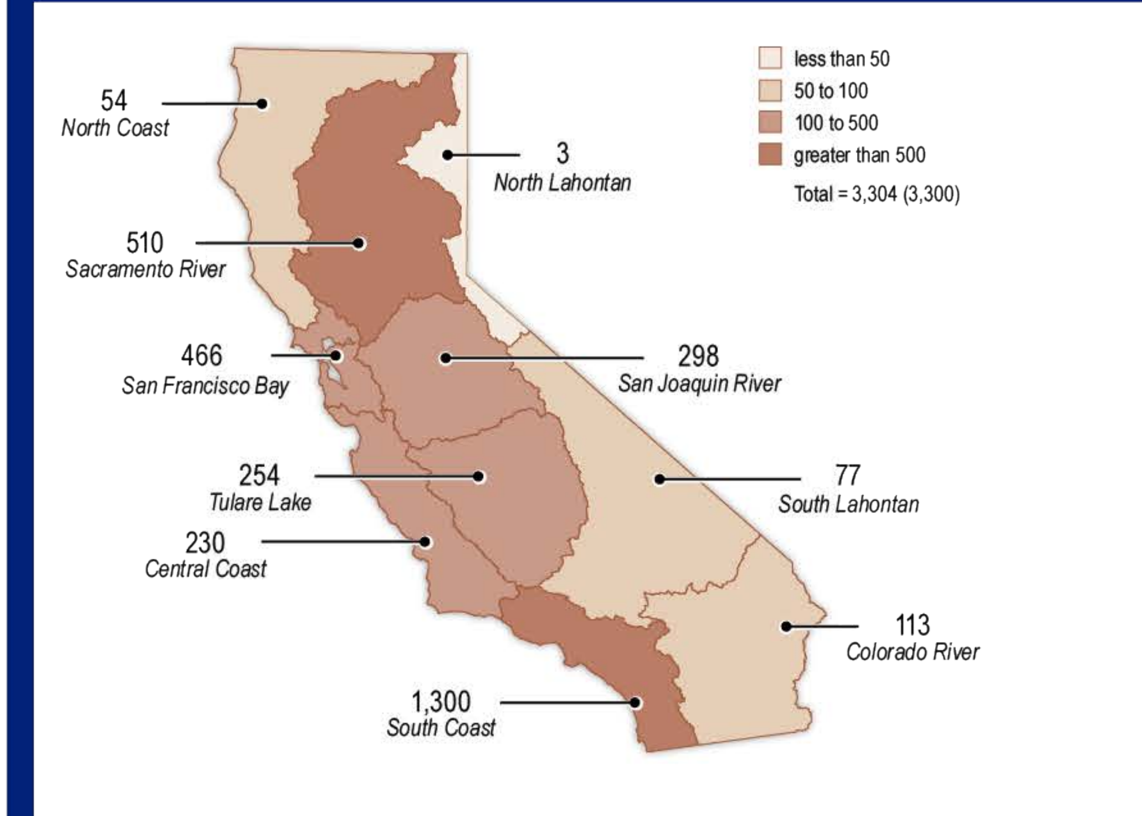
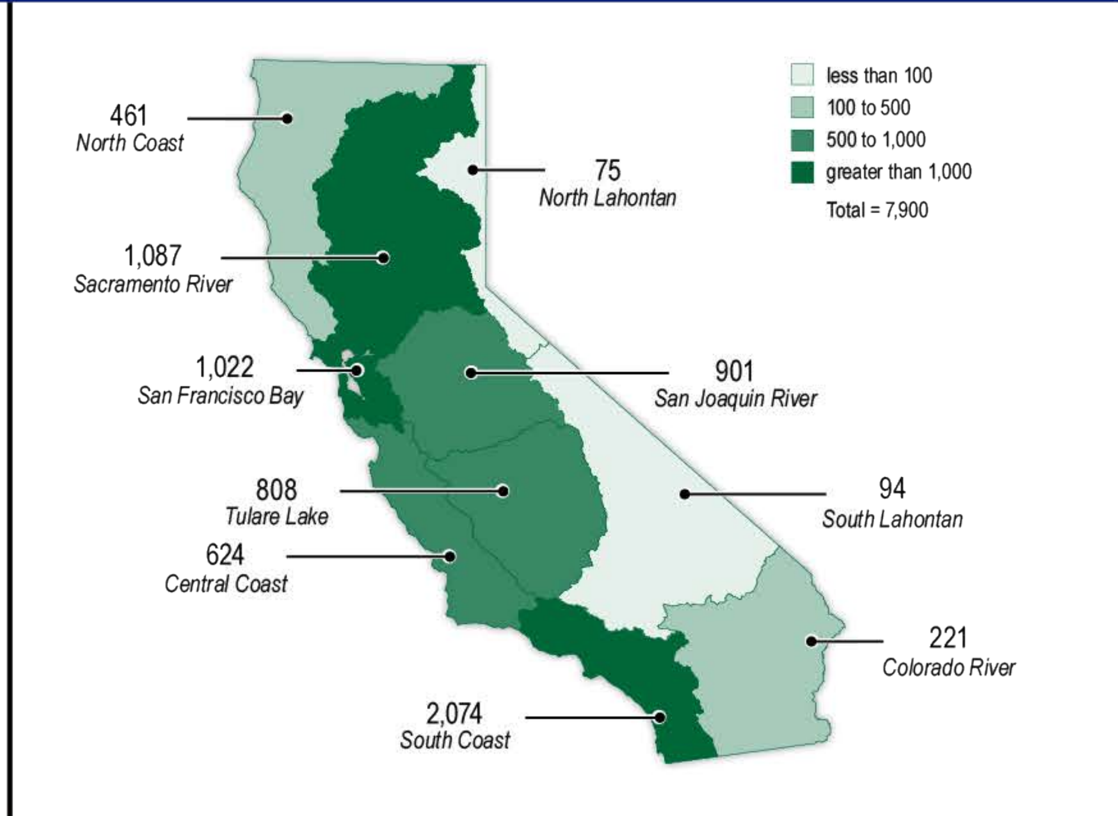
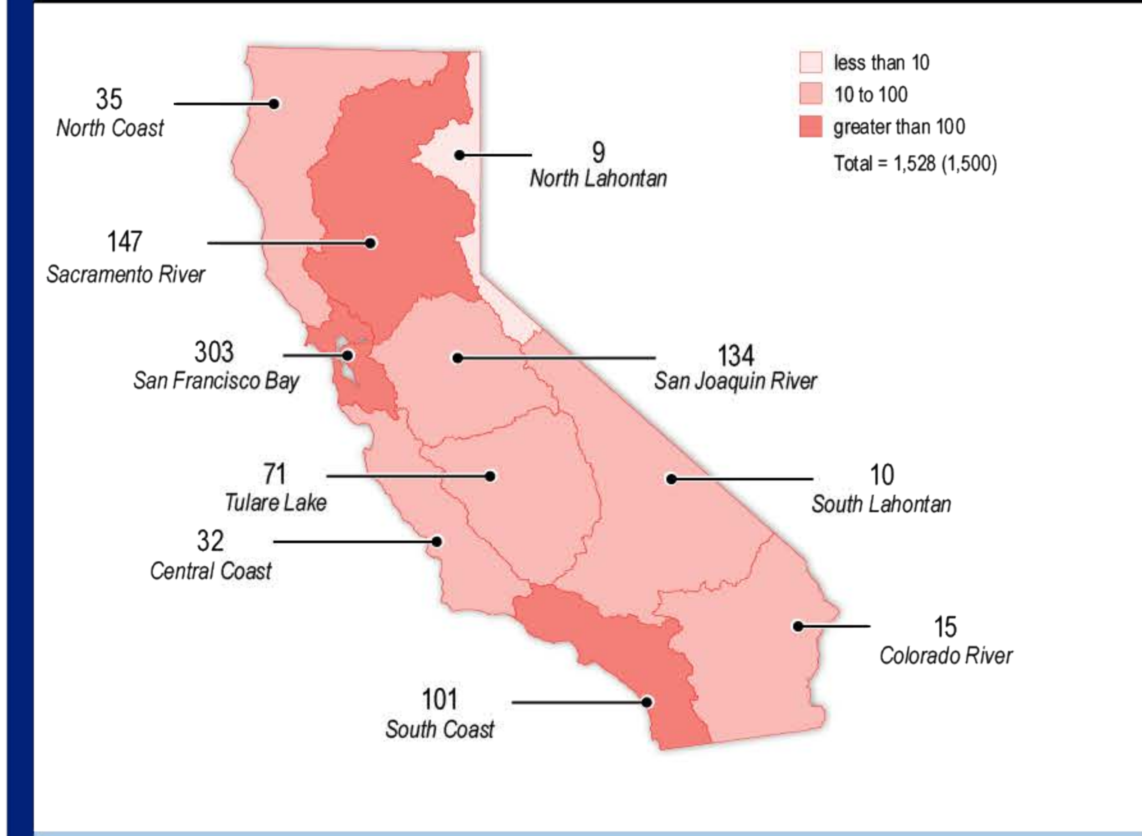


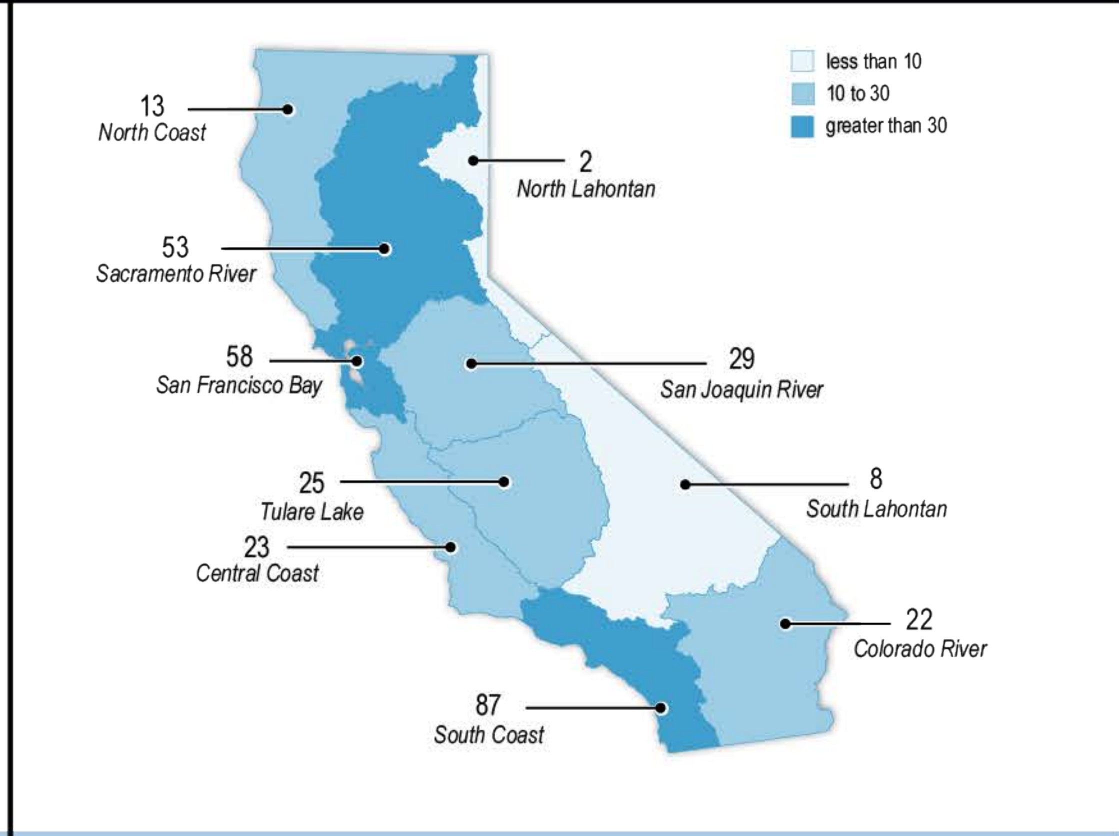
Essential Facilities Exposed by CWP Hydrologic Region



Transportation Facilities Exposed by CWP Hydrologic Region



High Potential Facilities Exposed by CWP Hydrologic Region



Lifeline Utilities Exposed by CWP Hydrologic Region

Figure F-30
Facilities Exposure to 500-Year Floodplain

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Native American Tribal Lands

Table F-14 shows the number of tribes and acreage of exposed Native American tribal lands in each CWP hydrologic region. The majority of exposed Native American tribal lands are in the Sacramento River and Colorado River hydrologic regions.

Table F-14. Exposed Native American Tribal Lands in Each CWP Hydrologic Region

CWP Hydrologic Region	Exposed Native American Tribal Lands			
	100-Year Floodplain		500-Year Floodplain	
	Number of Tribes	Acres	Number of Tribes	Acres
Central Coast	0	-	0	-
Colorado River	9	29,154	10	57,499
North Coast	4	5,568	4	5,748
North Lahontan	1	9	2	14
Sacramento River	8	2,747	8	2,833
San Francisco Bay	0	0	0	0
San Joaquin River	1	3	1	3
South Coast	5	583	5	586
South Lahontan	1	3	1	10
Tulare Lake	2	109	2	109
Overlay Regions				
Sacramento-San Joaquin Delta	0	0	0	0
Mountain Counties	2	412	2	412

4.2 Overview of Each CWP Hydrologic Region

4.2.1 Summary

This section provides an overview of the types of flooding that occur in California and then provides an overview of each CWP hydrologic region and overlay region, including its physical setting, summary of flood hazards, and an overview of the flood hazard exposure results for each region. Much of the information contained in the physical setting and flood hazards section for each region is taken from *California Local Flood Response and Recovery Plans: Identification of Flood Hazards* (DWR, 2009a). In addition, a list of historical flood events in each CWP hydrologic region and overlay region can be found in *Attachment C: History of California Flooding*.

4.2.2 Types of Flooding in California

Several types of flooding occur throughout the State of California. This is due to variations in:

- Weather and climate patterns (e.g., El Niño, La Niña, Pineapple Express)
- Hydrologic features

- Composition of soil and bedrock
- Type and density of vegetation
- Past and present human manipulations of the landscape
- Patterns of land use

These factors combine to bring about floods that can differ in characteristics, such as warning time, duration, depth, and resulting losses, depending on where, when, why, and how the flooding occurs.

Figure F-31 depicts the types of flooding that occur in California. The types of flooding in California can be divided into eight categories:

- Slow rise flooding – Gradual inundation as waterways or lakes overflow their banks. Most often caused by heavy precipitation, especially with heavy snowmelt. This type of flood includes riverine flooding in deep floodplains and ponding of water in low-lying urban areas, as well as gradual flooding in areas adjacent to local streams and creeks.
- Flash flooding – Quickly forming floods with high-velocity flows. Often caused by stationary or slow-moving storms. Typically occurs on steep slopes and impermeable surfaces, and in areas adjacent to local streams and creeks.
- Debris flow flooding – Flows made up of water, liquefied mud, and debris. Can form and accelerate quickly, reach high velocities, and travel great distances. Commonly caused by heavy localized rainfall on burned hillsides devoid of vegetation.
- Alluvial fan flooding – Flows of shallow depth and high velocity, with sediment transport, along uncertain flow paths on the surface and at the toe of alluvial fans. Typically caused by localized rainstorms, often with snowmelt.
- Coastal flooding – Inundation at locations normally above the level of high tide. Often caused by storm surge occurring with high tide.
- Tsunami flooding – High-speed seismic sea waves, triggered by mass movement that displaces a large volume of water. Causes include earthquakes and underwater landslides. Impact on land depends on wave height and inundation area.
- Stormwater flooding – Local stormwater flooding refers to localized flooding that occurs in urbanized areas during or after a storm event. Generally, the extent of flooding is confined to a smaller area compared to other types of flooding. Local stormwater flooding usually results from clogged or overwhelmed storm drain systems that became incapable of conveying stormwater runoff efficiently to outfalls into creeks and rivers.
- Engineered structure failure flooding – Flooding as a result of dam failure or levee failure presents the potential of catastrophic impact, depending on amount of water impounded and location of populated areas downstream.

All California communities are at risk of stormwater flooding, and most California communities are vulnerable to additional types of flooding.


Slow Rise Flooding
Gradual inundation as waterways or lakes overflow their banks. Most often caused by heavy precipitation, especially with heavy snowmelt. This type of flood includes riverine flooding in deep floodplains and ponding of water in low-lying urban areas, as well as gradual flooding in areas adjacent to local streams and creeks.


Flash Flooding
Quickly forming floods with high-velocity flows. Often caused by stationary or slow-moving storms. Typically occurs on steep slopes and impermeable surfaces, and in areas adjacent to local streams and creeks.


Debris Flow Flooding
Flows made up of water, liquefied mud, and debris. Can form and accelerate quickly, reach high velocities, and travel great distances. Commonly caused by heavy localized rainfall on burned hillsides devoid of vegetation.


Alluvial Fan Flooding
Flows of shallow depth and high velocity, with sediment transport, along uncertain flow paths on the surface and at the toe of alluvial fans. Typically caused by localized rainstorms, often with snowmelt.


Coastal Flooding
Inundation at locations normally above the level of high tide. Often caused by storm surge occurring with high tide.


Tsunami Flooding
High-speed seismic sea waves triggered by mass movement that displaces a large volume of water. Causes include earthquakes and underwater landslides. Impact on land depends on wave height and inundation area.


Stormwater Flooding
Local storm water flooding refers to localized flooding that occurs in urbanized areas during or after a storm event. Generally the extent of flooding is confined to a smaller area compared to other types of flooding. Local storm water flooding usually results from clogged or overwhelmed storm drain systems that became incapable of conveying storm water runoff efficiently to outfalls into creeks and rivers.


Engineered Structure Failure Flooding
Flooding as a result of dam failure or levee failure presents the potential of catastrophic impact, depending on amount of water impounded and location of populated areas downstream.

LEGEND
Potential Occurence by County
Absent Present Likely

US Army Corps of Engineers ®

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Figure F-31
Types of Flooding in California

August 29, 2013

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4.2.3 North Coast Hydrologic Region

Physical Setting

The North Coast Hydrologic Region includes approximately 19,500 square miles along the far northern areas of California. The region is primarily mountainous, rugged, and heavily forested, with some inland mountain valleys, and the high desert region of the Modoc Plateau. Significant geographic features include the Klamath River Basin, Hoopa Valley, Anderson Valley, Santa Rosa Plain, Klamath Mountains, the Coast Range, the high plateau area of Modoc County, and Mount Shasta. Major lakes and reservoirs include Clear, Tule, Lower Klamath, and Trinity lakes. Major streams or rivers include the Klamath, Eel, Smith, Mad, Russian, and Mattole rivers. Major cities include Crescent City, Eureka, Santa Rosa, Ukiah, and Yreka.

Common flood types:
- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Coastal

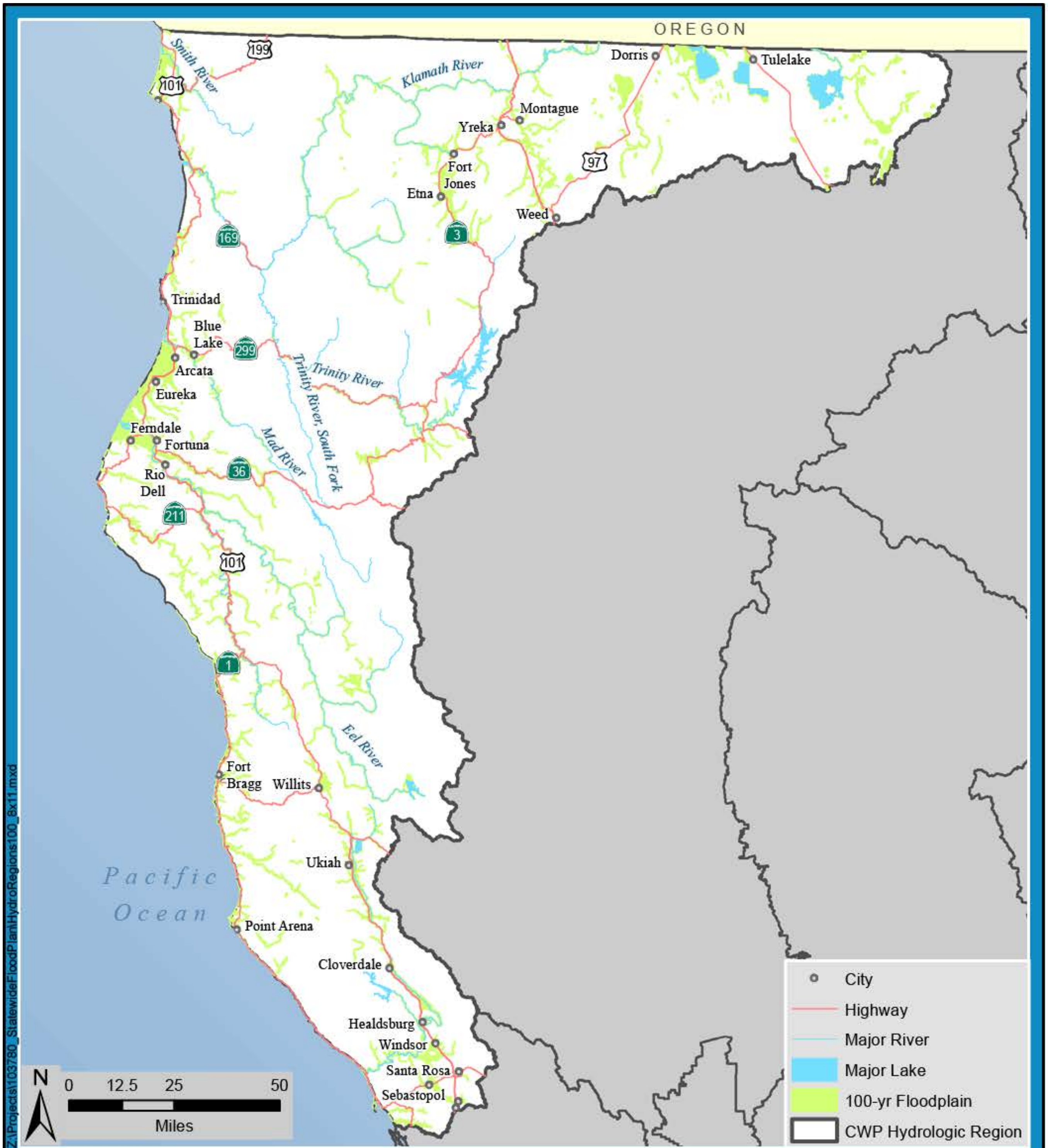
Other possible flood types:
- ✓ Debris flow
- ✓ Tsunami
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, and coastal flooding. Other possible flood types include tsunami, debris flow, and engineered structure failure. Because of heavy rainfall, land use practices, extremely high loads of sediment, and steep mountains, the region's rivers exhibit short lag times and cause very destructive floods. Flooding due to snowmelt is rare, primarily because of the region's proximity to the Pacific Ocean and relatively low-elevation mountains. High spring tides coupled with intense rainfall can cause flooding to shoreline communities, particularly in the Humboldt Bay area. Tsunamis caused by oceanic earthquakes also pose a real threat, particularly to the community of Crescent City in Del Norte County.

Description of Exposure to Flood Hazard Results

Figures F-32 and F-33 depict the 100-year and 500-year floodplains in the North Coast Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 33,000 people and 108,000 acres of agricultural crops are exposed in the 100-year floodplain, with more than 43,000 people and 112,000 acres of agricultural crops exposed in the 500-year floodplain. More than 200 sensitive plant species and 100 sensitive animal species are exposed in both the 100-year and 500-year floodplains. More than 510 facilities are exposed in the 100-year floodplain, and more than 560 facilities are exposed in the 500-year floodplain. Four Native American tribes are exposed to both the 100-year and 500-year floodplains in this region.



North Coast Key Results

Total Population:	636,800	Transportation Facilities:	429
Population Exposed:	33,300	Transportation Segments (miles):	330
Percent of Population Exposed:	5	Essential Facilities:	45
Exposed Structures:	17,400	Lifeline Utilities:	10
Value of Exposed Structure and Contents:	$3.0 Billion	Dept. of Defense Facilities:	-
		Dept. of Defense Facilities (acres):	-
Total Area (acres)	12.4 Million	High Potential Loss Facilities:	32
Exposed Area (acres)	400,800	Native American Tribes:	4
Percent of Area Exposed:	3	Native American Tribal Lands (acres):	5,568
Exposed Ag.Crops (acres):	108,300	Sensitive Animal Species Exposed:	117
Percent of Ag. Crops Exposed:	25	Sensitive Plant Species Exposed:	203
Value of Exposed Ag. Crops:	$84.0 Million		

Figure F-32
Statewide Flood Hazard Exposure Summary for the North Coast Hydrologic Region 100-year Floodplain

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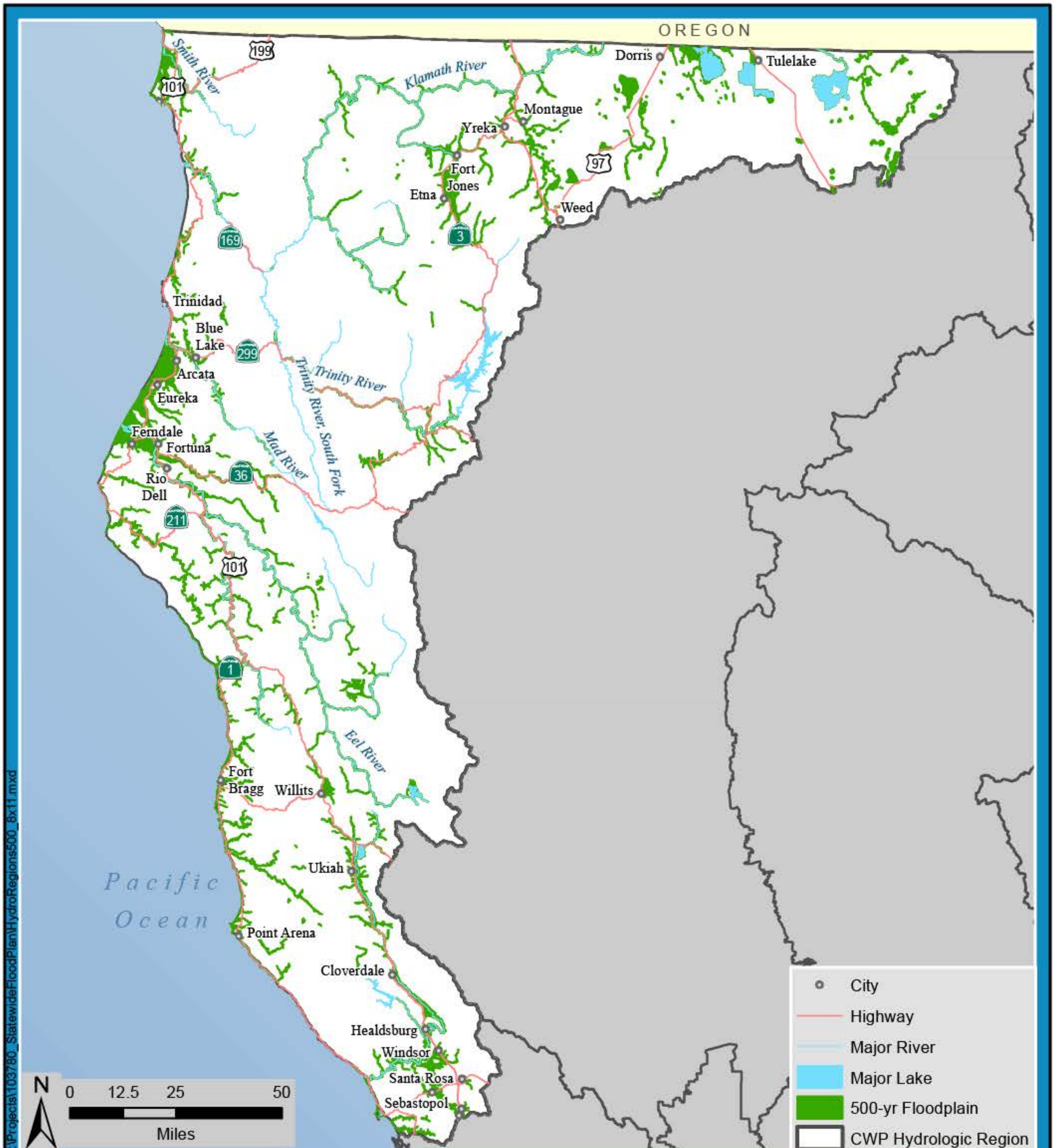

North Coast Key Results

Total Population:	636,800	Transportation Facilities:	461
Population Exposed:	43,400	Transportation Segments (miles):	355
Percent of Population Exposed:	7	Essential Facilities:	54
Exposed Structures:	22,600	Lifeline Utilities:	13
Value of Exposed Structure and Contents:	$4.2 Billion	Dept. of Defense Facilities:	-
Total Area (acres)	12.4 Million	Dept. of Defense Facilities (acres):	-
Exposed Area (acres)	412,400	High Potential Loss Facilities:	35
Percent of Area Exposed:	3	Native American Tribes:	4
Exposed Ag.Crops (acres):	112,200	Native American Tribal Lands (acres):	5,748
Percent of Ag. Crops Exposed:	26	Sensitive Animal Species Exposed:	117
Value of Exposed Ag. Crops:	$87.7 Million	Sensitive Plant Species Exposed:	203

Figure F-33

Statewide Flood Hazard Exposure Summary for the North Coast Hydrologic Region 500-year Floodplain

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4.2.4 San Francisco Bay Hydrologic Region

Physical Setting

The San Francisco Bay Hydrologic Region covers approximately 4,500 square miles. Significant physical features include the San Francisco, Suisun, and San Pablo bays; and the Coast Range, Diablo Range, and Santa Cruz mountains. Major lakes and reservoirs include San Andreas Lake and Crystal Springs Reservoir. Major streams and rivers in the region include Guadalupe River, Coyote Creek, Alameda Creek, Napa River, and Sonoma Creek. Major cities include San Francisco, Oakland, and San Jose.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Coastal

Other possible flood types:

- ✓ Tsunami
- ✓ Engineered structure failure
- ✓ Debris flow

Flood Hazards

Common flood types include stormwater, slow rise, flash, and coastal flooding. Other possible flood types include debris flow, tsunami, and engineered structure failure. Flooding originates primarily from intense rainstorms. The northern portion of the region receives more precipitation and experiences floods more often than the southern portion. Flooding occurs most frequently in winter and spring; the steep terrain results in floods that are intense and of short duration. Valley flooding tends to occur when large, widespread storms fall on previously saturated watersheds. The greatest flood damages occur in low-gradient lower reaches when channels overflow and floodwaters spread through urban neighborhoods. Hillsides denuded by wildfires can exacerbate flood-induced damages with increased runoff and sediment. Flooding at river mouths is frequent, and storm surges coincident with high tides can create severe flooding in low-lying areas.

Description of Exposure to Flood Hazard Results

Figures F-34 and F-35 depict the 100-year and 500-year floodplains in the San Francisco Bay Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 355,000 people and 33,000 acres of agricultural crops are exposed in the 100-year floodplain, with more than one million people and 44,000 acres of agricultural crops exposed in the 500-year floodplain. More than 150 sensitive plant species and 100 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 920 facilities are exposed in the 100-year floodplain, and more than 1,800 facilities are exposed in the 500-year floodplain. No Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.

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San Francisco Bay Key Results

Total Population:	6,066,100	Transportation Facilities:	560
Population Exposed:	355,000	Transportation Segments (miles):	361
Percent of Population Exposed:	6	Essential Facilities:	140
Exposed Structures:	109,800	Lifeline Utilities:	47
Value of Exposed Structure and Contents:	$46.2 Billion	Dept. of Defense Facilities:	8
Total Area (acres)	2.9 Million	Dept. of Defense Facilities (acres):	2,813
Exposed Area (acres)	446,000	High Potential Loss Facilities:	168
Percent of Area Exposed:	15	Native American Tribes:	-
Exposed Ag.Crops (acres):	33,300	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	23	Sensitive Animal Species Exposed:	106
Value of Exposed Ag. Crops:	$17.3 Million	Sensitive Plant Species Exposed:	167

Figure F-34

Statewide Flood Hazard Exposure Summary for the San Francisco Bay Hydrologic Region 100-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

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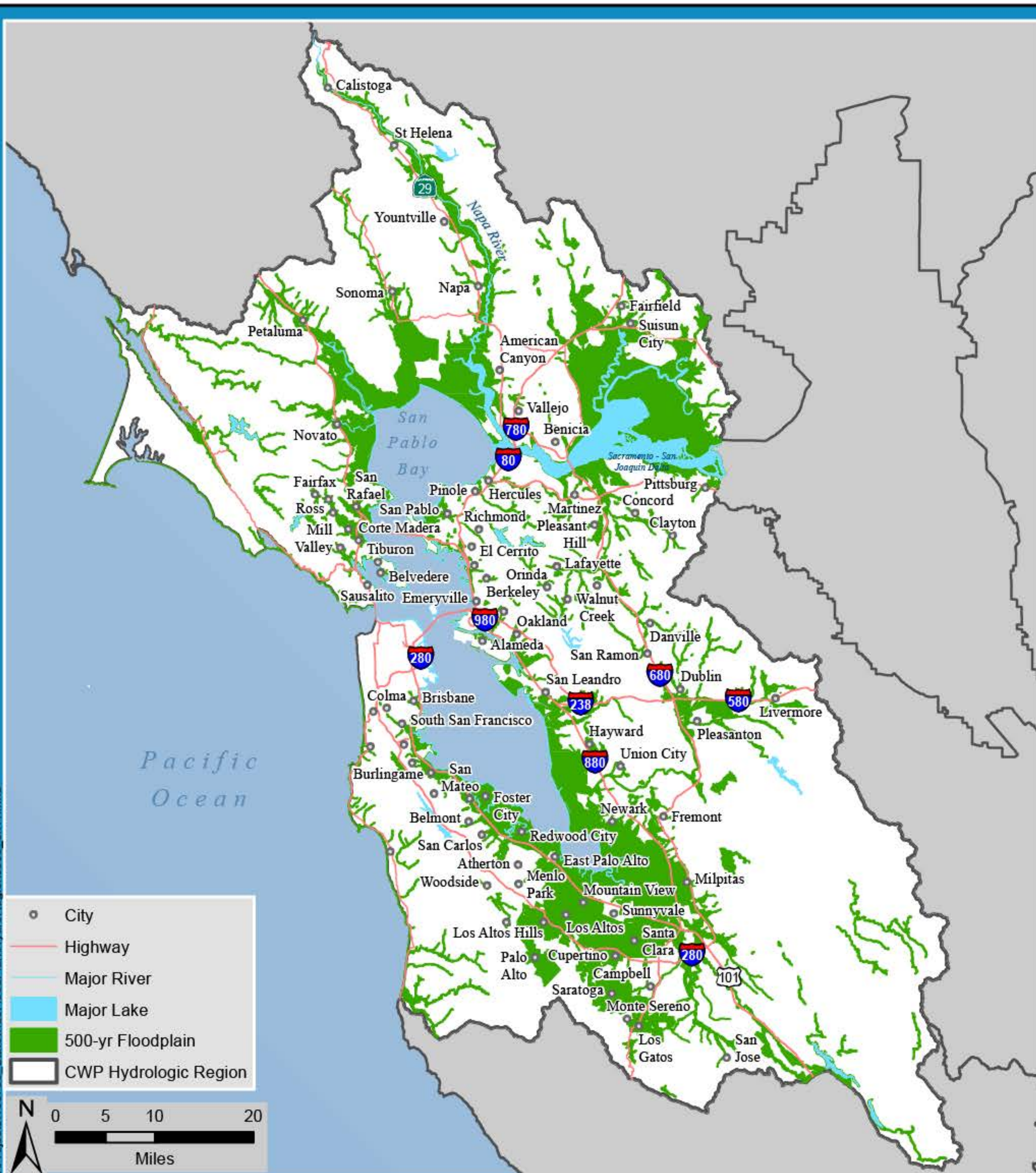

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San Francisco Bay Key Results

Total Population:	6,066,100	Transportation Facilities:	1,022
Population Exposed:	1,041,400	Transportation Segments (miles):	709
Percent of Population Exposed:	17	Essential Facilities:	466
Exposed Structures:	322,700	Lifeline Utilities:	58
Value of Exposed Structure and Contents:	$133.8 Billion	Dept. of Defense Facilities:	8
Total Area (acres)	2.9 Million	Dept. of Defense Facilities (acres):	2,914
Exposed Area (acres)	553,600	High Potential Loss Facilities:	303
Percent of Area Exposed:	19	Native American Tribes:	-
Exposed Ag.Crops (acres):	44,000	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	31	Sensitive Animal Species Exposed:	110
Value of Exposed Ag. Crops:	$23.9 Million	Sensitive Plant Species Exposed:	169

Figure F-35

Statewide Flood Hazard Exposure Summary for the San Francisco Bay Hydrologic Region 500-year Floodplain

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4.2.5 Central Coast Hydrologic Region

Physical Setting

The Central Coast Hydrologic Region encompasses approximately 11,300 square miles along the coast of California. Significant physical features include Monterey and Morro bays, coastal mountains, coastal plains, inland valleys, and irrigated agriculture in the valleys. Major lakes and reservoirs include San Antonio, Nacimiento, and Twitchell reservoirs. Major streams and rivers include Salinas, Santa Ynez, Santa Maria, San Lorenzo, Pajaro, Carmel, and Big Sur rivers. Major cities include Santa Cruz, Salinas, Monterey, Paso Robles, San Luis Obispo, Santa Maria, and Santa Barbara.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Alluvial fan
- ✓ Coastal

Other possible flood types:

- ✓ Debris flow
- ✓ Tsunami
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, alluvial fan, and coastal flooding. Other possible flood types include debris flow, tsunami, and engineered structure failure. Streams draining the mountains of the Central Coast are subject to short, intense floods, causing frequent flood damage in agricultural and urban areas. Steep slopes in the upper watersheds undergo severe erosion during storm runoff, depositing large amounts of sediment on floodplains. Wildfires exacerbate sediment loading to rivers in upper watersheds with increased rainsplash erosion rates and high-velocity sheet flows.

Description of Exposure to Flood Hazard Results

Figures F-36 and F-37 depict the 100-year and 500-year floodplains in the Central Coast Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. About 93,000 people and 124,000 acres of agricultural crops are exposed in the 100-year floodplain, with approximately 427,000 people and over 146,000 acres of agricultural crops exposed in the 500-year floodplain. More than 200 sensitive plant species and 100 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 560 facilities are exposed in the 100-year floodplain, and more than 900 facilities are exposed in the 500-year floodplain. No Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.

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Central Coast Key Results

Total Population:	1,447,400	Transportation Facilities:	466
Population Exposed:	92,700	Transportation Segments (miles):	275
Percent of Population Exposed:	6	Essential Facilities:	50
Exposed Structures:	31,600	Lifeline Utilities:	23
Value of Exposed Structure and Contents:	$10.3 Billion	Dept. of Defense Facilities:	5
Total Area (acres)	7.2 Million	Dept. of Defense Facilities (acres):	13,480
Exposed Area (acres)	336,000	High Potential Loss Facilities:	24
Percent of Area Exposed:	5	Native American Tribes:	-
Exposed Ag.Crops (acres):	123,600	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	18	Sensitive Animal Species Exposed:	111
Value of Exposed Ag. Crops:	$564.6 Million	Sensitive Plant Species Exposed:	202

Figure F-36

Statewide Flood Hazard Exposure Summary for the Central Coast Hydrologic Region 100-year Floodplain

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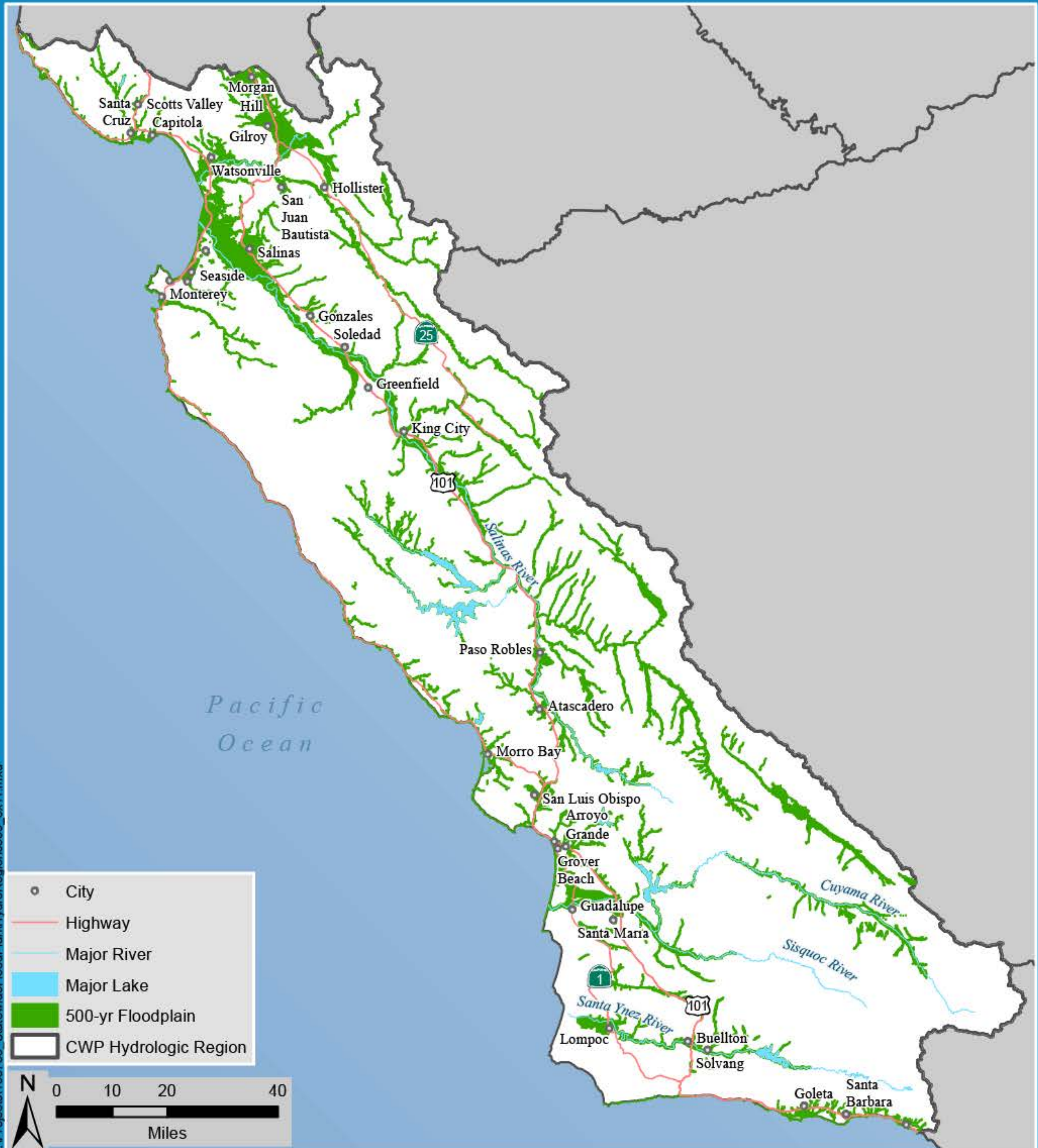

Central Coast Key Results

Total Population:	1,447,400	Transportation Facilities:	624
Population Exposed:	426,900	Transportation Segments (miles):	412
Percent of Population Exposed:	29	Essential Facilities:	230
Exposed Structures:	125,400	Lifeline Utilities:	33
Value of Exposed Structure and Contents:	$36.3 Billion	Dept. of Defense Facilities:	5
Total Area (acres)	7.2 Million	Dept. of Defense Facilities (acres):	15,322
Exposed Area (acres)	393,500	High Potential Loss Facilities:	32
Percent of Area Exposed:	5	Native American Tribes:	-
Exposed Ag.Crops (acres):	146,300	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	21	Sensitive Animal Species Exposed:	112
Value of Exposed Ag. Crops:	$689.3 Million	Sensitive Plant Species Exposed:	204

Figure F-37
Statewide Flood Hazard Exposure Summary for the Central Coast Hydrologic Region 500-year Floodplain

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4.2.6 South Coast Hydrologic Region

Physical Setting

The South Coast Hydrologic Region includes approximately 10,600 square miles along the Pacific Coast from northern Ventura County south to the border of Mexico, and east to the San Gabriel, San Bernardino, and San Jacinto mountains. Significant geographic features include the Coastal Plain, the central Transverse Ranges, the Peninsular Ranges, and the San Fernando, San Gabriel, Santa Ana, and Santa Clara river valleys. Major lakes and reservoirs include Lake Casitas, Castaic Lake, Big Bear Lake, Lake Mathews, and Morena Lake. Many of the rivers in this region have been channelized and lined with concrete, and are seasonal low-flow rivers. Major cities include Ventura, Los Angeles, Long Beach, Santa Ana, San Bernardino, and San Diego.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Debris flow
- ✓ Alluvial fan
- ✓ Coastal

Other possible flood types:

- ✓ Tsunami
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, debris flow, alluvial fan, and coastal flooding. Other possible flood types include tsunami and engineered structure failure. Flooding in this region is predominately from winter storms. Precipitation over short periods can produce large amounts of water in the steep upper watersheds, often leading to very sudden and severe flooding of developed lowland areas. Debris flows are a common occurrence during the winter months. Seasonal fires denude the watersheds of vegetation and can leave steep terrain vulnerable to winter storms. Thunderstorms are infrequent in the region, and typically occur only at low elevations during the winter months.

Description of Exposure to Flood Hazard Results

Figures F-38 and F-39 depict the 100-year and 500-year floodplains in the South Coast Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 393,000 people and 46,000 acres of agricultural crops are exposed in the 100-year floodplain, with more than 3,410,000 people and approximately 80,000 acres of agricultural crops exposed in the 500-year floodplain. More than 200 sensitive plant species and 130 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 1,100 facilities are exposed in the 100-year floodplain, and more than 4,200 facilities are exposed in the 500-year floodplain. Five Native American tribes are exposed to 100-year and 500-year floodplains in this region.

South Coast Key Results

Total Population:	18,066,400	Transportation Facilities:	803
Population Exposed:	393,100	Transportation Segments (miles):	423
Percent of Population Exposed:	2	Essential Facilities:	165
Exposed Structures:	116,100	Lifeline Utilities:	21
Value of Exposed Structure and Contents:	$35.7 Billion	Dept. of Defense Facilities:	16
Total Area (acres)	7.0 Million	Dept. of Defense Facilities (acres):	1,252
Exposed Area (acres)	262,200	High Potential Loss Facilities:	101
Percent of Area Exposed:	4	Native American Tribes:	5
Exposed Ag.Crops (acres):	46,200	Native American Tribal Lands (acres):	583
Percent of Ag. Crops Exposed:	12	Sensitive Animal Species Exposed:	136
Value of Exposed Ag. Crops:	$216.0 Million	Sensitive Plant Species Exposed:	210

Figure F-38
Statewide Flood Hazard Exposure Summary for the South Coast Hydrologic Region 100-year Floodplain

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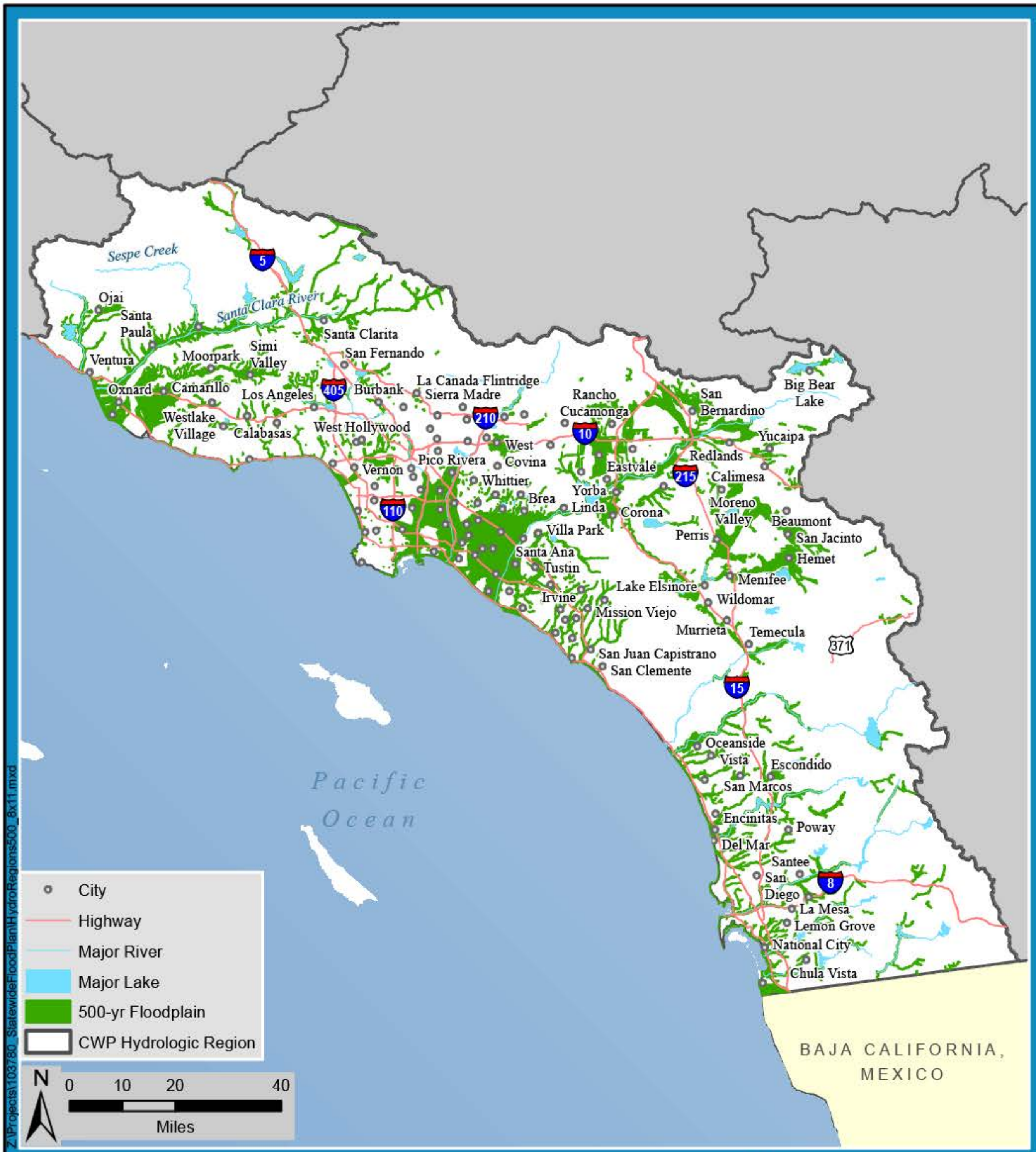

South Coast Key Results

Total Population:	18,066,400	Transportation Facilities:	2,074
Population Exposed:	3,411,900	Transportation Segments (miles):	1,626
Percent of Population Exposed:	19	Essential Facilities:	1,299
Exposed Structures:	883,100	Lifeline Utilities:	87
Value of Exposed Structure and Contents:	$231.3 Billion	Dept. of Defense Facilities:	16
Total Area (acres)	7.0 Million	Dept. of Defense Facilities (acres):	4,337
Exposed Area (acres)	578,400	High Potential Loss Facilities:	772
Percent of Area Exposed:	8	Native American Tribes:	5
Exposed Ag.Crops (acres):	79,900	Native American Tribal Lands (acres):	586
Percent of Ag. Crops Exposed:	20	Sensitive Animal Species Exposed:	137
Value of Exposed Ag. Crops:	$424.8 Million	Sensitive Plant Species Exposed:	210

Figure F-39

Statewide Flood Hazard Exposure Summary for the South Coast Hydrologic Region 500-year Floodplain

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4.2.7 Sacramento River Hydrologic Region

Physical Setting

The Sacramento River Hydrologic Region encompasses approximately 27,200 square miles in the northern central area of California. The region is the drainage area of the Sacramento River, the largest river in the state. Most of the mountainous portions of the region are heavily forested. The region includes the Coast Range, southern Klamath Mountains, southern Cascade Mountains, western Sierra Nevada Mountains, and the Sacramento Valley. In the foothill areas, suburban and rural housing developments are built along major highway corridors. Major lakes and reservoirs include Goose Lake, Shasta Lake, Clear Lake, Lake Almador, Lake Oroville, Lake Berryessa, and Folsom Lake. Major streams and rivers include Sacramento, American, Bear, Yuba, Feather, and Pit rivers. Major cities include Sacramento, Yuba City, Oroville, Chico, and Redding.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash

Other possible flood types:

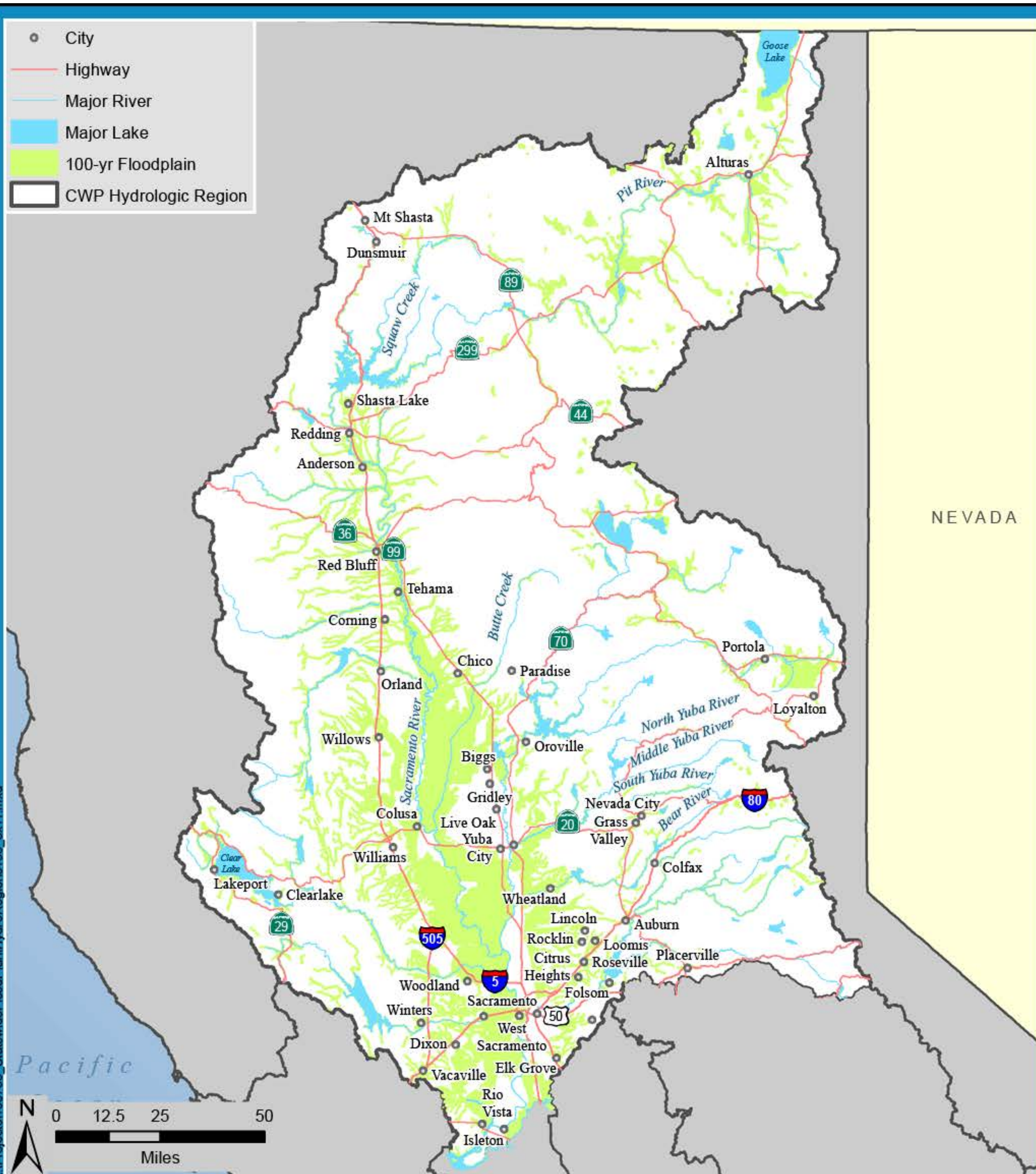
- ✓ Debris flow
- ✓ Alluvial fan
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, and flash flooding. Other possible flood types include debris flow, alluvial fan, and engineered structure failure. Floods within the Sacramento River region originate principally from heavy rainfall. Most flood events occur in December and January as a result of multiple storms and saturated soil conditions, but floods can occur in October and November or during the late winter or early spring months.

Description of Exposure to Flood Hazard Results

Figures F-40 and F-41 depict the 100-year and 500-year floodplains in the Sacramento River Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 200,000 people and 897,000 acres of agricultural crops are exposed in the 100-year floodplain, with about 926,000 people and 1,200,000 acres of agricultural crops exposed in the 500-year floodplain. More than 200 sensitive plant species and 140 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 1,300 facilities are exposed in the 100-year floodplain, and more than 2,300 facilities are exposed in the 500-year floodplain. Eight Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.



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Sacramento River Key Results

Total Population:	2,570,300	Transportation Facilities:	1,087
Population Exposed:	200,200	Transportation Segments (miles):	626
Percent of Population Exposed:	8	Essential Facilities:	135
Exposed Structures:	75,000	Lifeline Utilities:	25
Value of Exposed Structure and Contents:	$16.7 Billion	Dept. of Defense Facilities:	5
Total Area (acres)	17.4 Million	Dept. of Defense Facilities (acres):	4,970
Exposed Area (acres)	1,737,300	High Potential Loss Facilities:	108
Percent of Area Exposed:	10	Native American Tribes:	8
Exposed Ag.Crops (acres):	896,900	Native American Tribal Lands (acres):	2,747
Percent of Ag. Crops Exposed:	40	Sensitive Animal Species Exposed:	142
Value of Exposed Ag. Crops:	$1.1 Billion	Sensitive Plant Species Exposed:	203

Figure F-40
Statewide Flood Hazard Exposure Summary for the Sacramento River Hydrologic Region 100-year Floodplain

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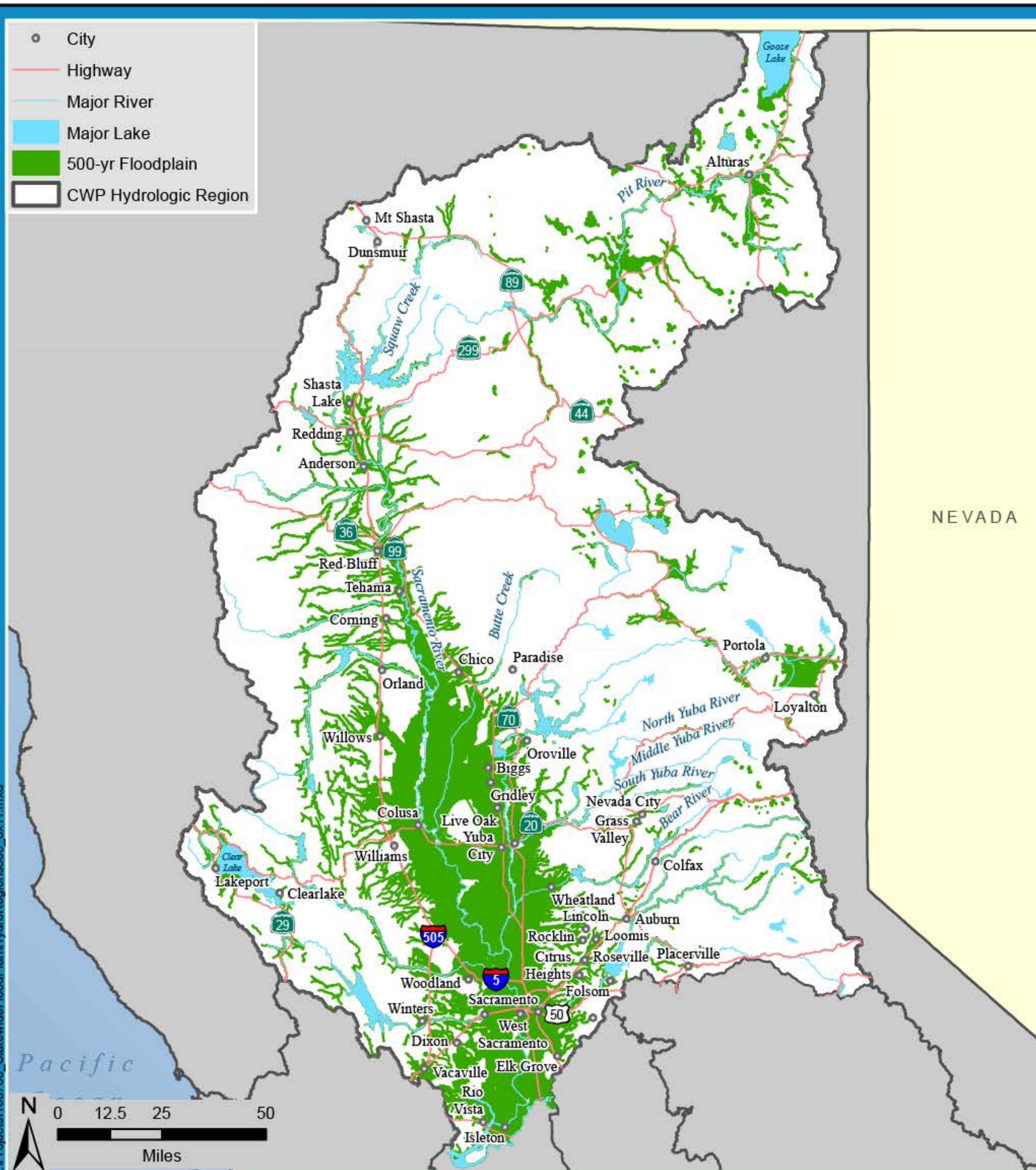

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Sacramento River Key Results

Total Population:	2,570,300	Transportation Facilities:	1,620
Population Exposed:	925,800	Transportation Segments (miles):	1,191
Percent of Population Exposed:	36%	Essential Facilities:	510
Exposed Structures:	320,800	Lifeline Utilities:	53
Value of Exposed Structure and Contents:	$66.3 Billion	Dept. of Defense Facilities:	6
Total Area (acres)	17.4 Million	Dept. of Defense Facilities (acres):	5,841
Exposed Area (acres)	2,242,400	High Potential Loss Facilities:	147
Percent of Area Exposed:	13%	Native American Tribes:	8
Exposed Ag.Crops (acres):	1,215,500	Native American Tribal Lands (acres):	2,833
Percent of Ag. Crops Exposed:	54%	Sensitive Animal Species Exposed:	142
Value of Exposed Ag. Crops:	$1.7 Billion	Sensitive Plant Species Exposed:	205

Figure F-41

Statewide Flood Hazard Exposure Summary for the Sacramento River Hydrologic Region 500-year Floodplain

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4.2.8 San Joaquin River Hydrologic Region

Physical Setting

The San Joaquin River Hydrologic Region encompasses approximately 15,200 square miles in California's Central Valley. Significant features include the northern half of the San Joaquin Valley, the southern part of the Sacramento-San Joaquin Delta, the Sierra Nevada, and Diablo Range. Major lakes and reservoirs include Hensley Lake, Eastman Lake, Lake McClure, New Don Pedro Lake, New Melones Lake, Camanche Reservoir, and Millerton Lake. Major streams and rivers include Fresno, Chowchilla, Merced, Tuolumne, Stanislaus, Mokelumne, San Joaquin, and Cosumnes rivers. Major cities include Merced, Modesto, and Stockton.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash

Other possible flood types:

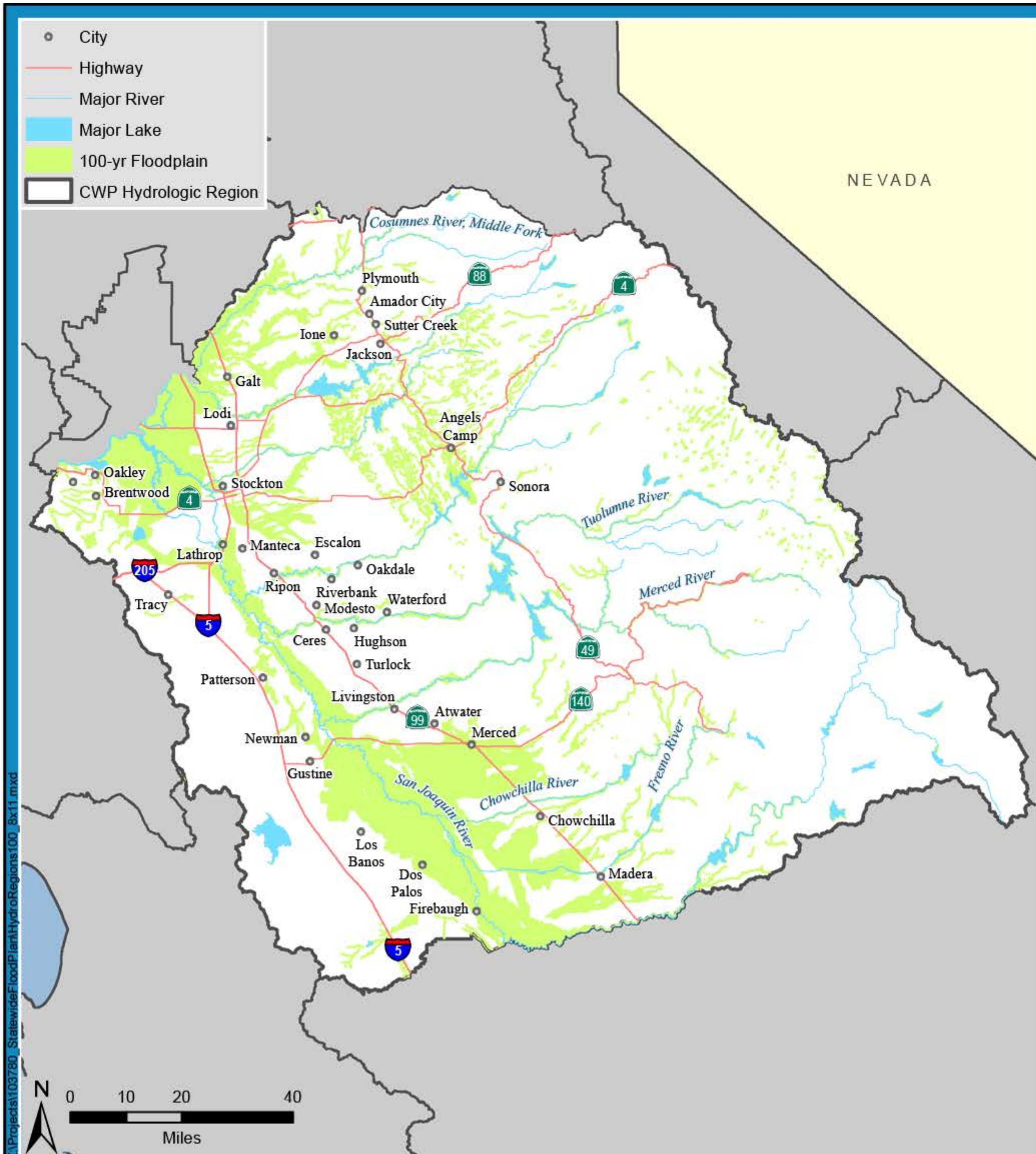
- ✓ Debris flow
- ✓ Alluvial fan
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, and flash flooding. Other possible flood types include debris flow, alluvial fan, and engineered structure failure. Floods in the San Joaquin Valley originate principally from melting of the Sierra snowpack and from rainfall. Flooding from snowmelt typically occurs in the spring and has a lengthy runoff period. Flooding from rainfall occurs in the winter and early spring, particularly when storms arriving from the Gulf of Alaska draw moisture-laden air from the tropics.

Description of Exposure to Flood Hazard Results

Figures F-42 and F-43 depict the 100-year and 500-year floodplains in the San Joaquin River Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 157,000 people and 682,000 acres of agricultural crops are exposed in the 100-year floodplain, with about 536,000 people and 879,000 acres of agricultural crops exposed in the 500-year floodplain. More than 125 sensitive plant species and 125 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 840 facilities are exposed in the 100-year floodplain, and more than 1,300 facilities are exposed in the 500-year floodplain. One Native American tribal land area is exposed to 100-year and 500-year floodplains in this region.



San Joaquin River Key Results

Total Population:	1,752,400	Transportation Facilities:	646
Population Exposed:	157,100	Transportation Segments (miles):	428
Percent of Population Exposed:	9	Essential Facilities:	93
Exposed Structures:	54,200	Lifeline Utilities:	12
Value of Exposed Structure and Contents:	$11.3 Billion	Dept. of Defense Facilities:	2
		Dept. of Defense Facilities (acres):	597
Total Area (acres)	9.8 Million	High Potential Loss Facilities:	92
Exposed Area (acres)	1,149,200	Native American Tribes:	1
Percent of Area Exposed:	12	Native American Tribal Lands (acres):	3
Exposed Ag.Crops (acres):	682,100	Sensitive Animal Species Exposed:	131
Percent of Ag. Crops Exposed:	32	Sensitive Plant Species Exposed:	130
Value of Exposed Ag. Crops:	$1.4 Billion		

Figure F-42

Statewide Flood Hazard Exposure Summary for the San Joaquin River Hydrologic Region 100-year Floodplain

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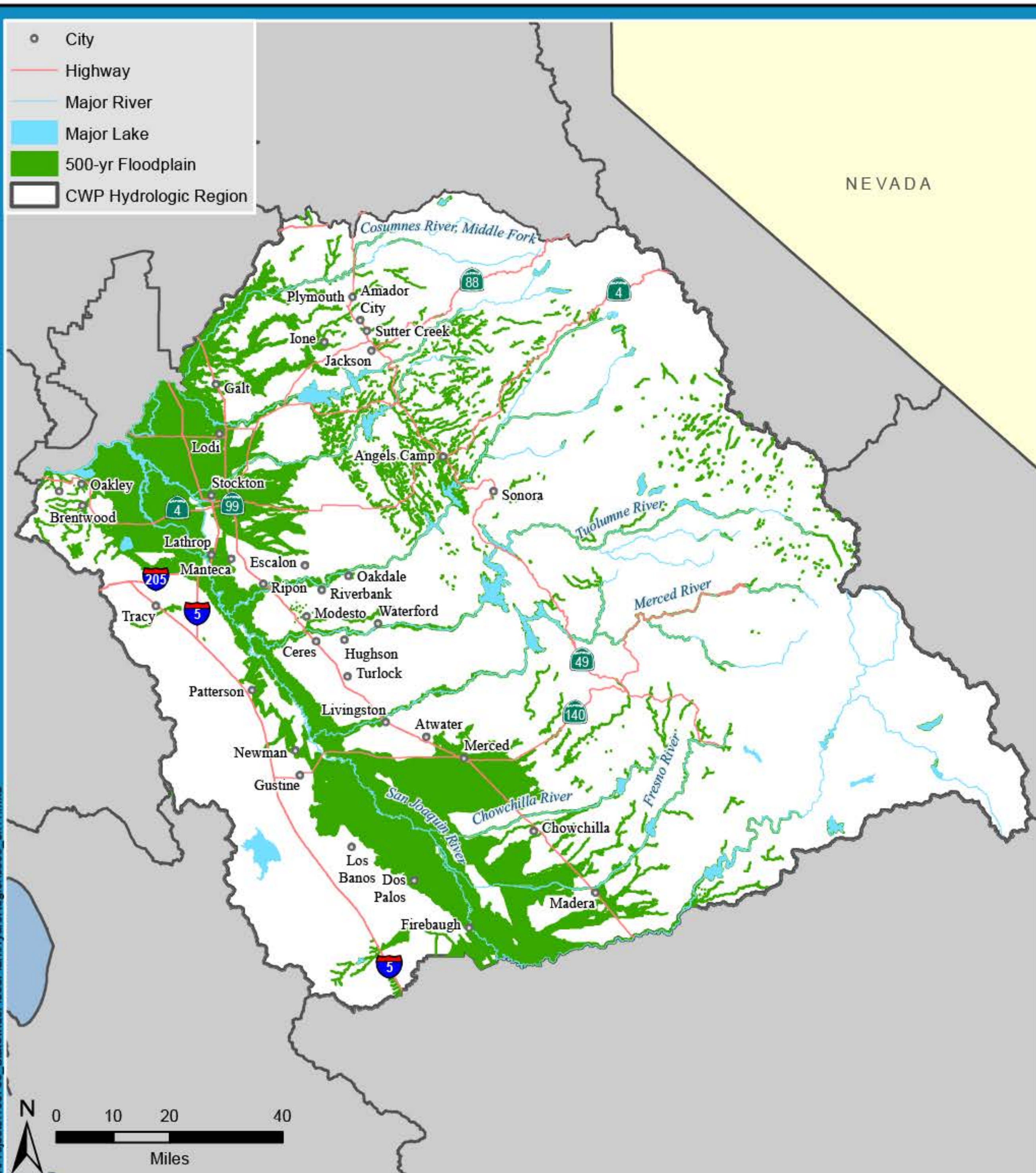

San Joaquin River Key Results

Total Population:	1,752,400	Transportation Facilities:	901
Population Exposed:	535,300	Transportation Segments (miles):	718
Percent of Population Exposed:	31	Essential Facilities:	298
Exposed Structures:	172,300	Lifeline Utilities:	29
Value of Exposed Structure and Contents:	$39.6 Billion	Dept. of Defense Facilities:	2
Total Area (acres)	9.8 Million	Dept. of Defense Facilities (acres):	831
Exposed Area (acres)	1,418,400	High Potential Loss Facilities:	134
Percent of Area Exposed:	14	Native American Tribes:	1
Exposed Ag.Crops (acres):	878,700	Native American Tribal Lands (acres):	3
Percent of Ag. Crops Exposed:	41	Sensitive Animal Species Exposed:	131
Value of Exposed Ag. Crops:	$1.9 Billion	Sensitive Plant Species Exposed:	131

Figure F-43

Statewide Flood Hazard Exposure Summary for the San Joaquin River Hydrologic Region 500-year Floodplain

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4.2.9 Tulare Lake Hydrologic Region

Physical Setting

The Tulare Lake Hydrologic Region includes approximately 17,000 square miles in the center of California. Significant geographic features include the southern half of the San Joaquin Valley, the Temblor Range to the west, the Tehachapi Mountains to the south, and the southern Sierra Nevada to the east. With no outlet to the sea, the area naturally drains to the Tulare, Buena Vista, and Kern lakebeds (natural drainage sinks converted to agricultural areas). Major lakes and reservoirs include Pine Flat Lake, Lake Kaweah, Lake Success, and Lake Isabella. Major streams and rivers include Kings, Kaweah, Tule, and Kern rivers. Major cities include Bakersfield, Visalia, Fresno, Clovis, Tulare, and Delano.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Debris flow

Other possible flood types:

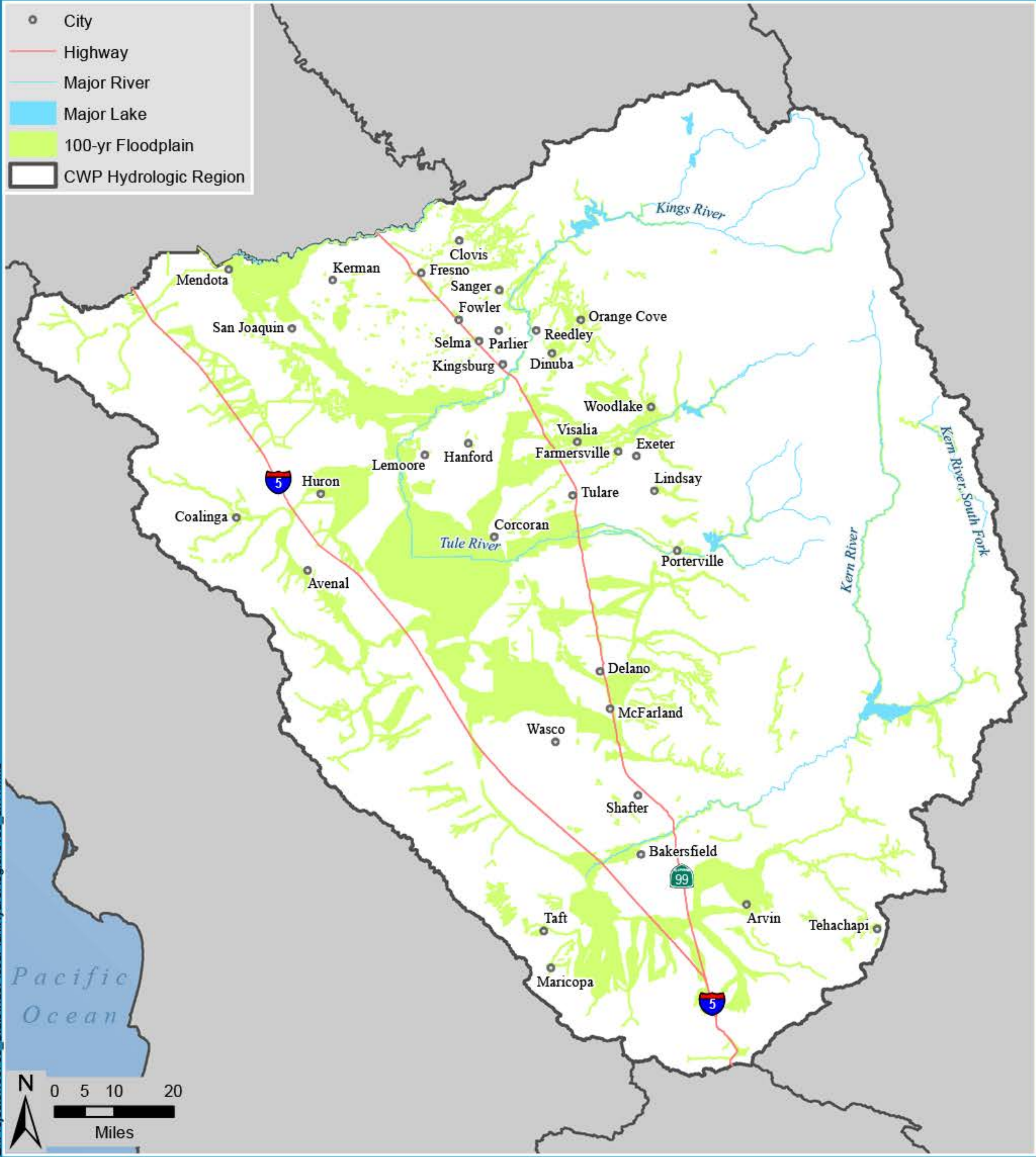
- ✓ Alluvial fan
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, and debris flow flooding. Other possible flood types include alluvial fan and engineered structure failure. Floods in the Tulare Lake region are caused by rainfall, snowmelt, and the resultant rise of normally dry lakes.

Description of Exposure to Flood Hazard Results

Figures F-44 and F-45 depict the 100-year and 500-year floodplains in the Tulare Lake Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 134,000 people and 802,000 acres of agricultural crops are exposed in the 100-year floodplain, with about 498,000 people and 990,000 acres of agricultural crops exposed in the 500-year floodplain. More than 90 sensitive plant species and 100 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 670 facilities are exposed in the 100-year floodplain, and more than 1,100 facilities are exposed in the 500-year floodplain. Two Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.



Tulare Lake Key Results

Total Population:	1,870,500	Transportation Facilities:	538
Population Exposed:	134,100	Transportation Segments (miles):	487
Percent of Population Exposed:	7	Essential Facilities:	71
Exposed Structures:	41,200	Lifeline Utilities:	11
Value of Exposed Structure and Contents:	$8.3 Billion	Dept. of Defense Facilities:	7
Total Area (acres)	10.8 Million	Dept. of Defense Facilities (acres):	25,143
Exposed Area (acres)	1,211,100	High Potential Loss Facilities:	50
Percent of Area Exposed:	11	Native American Tribes:	2
Exposed Ag.Crops (acres):	802,200	Native American Tribal Lands (acres):	109
Percent of Ag. Crops Exposed:	23	Sensitive Animal Species Exposed:	101
Value of Exposed Ag. Crops:	$1.8 Billion	Sensitive Plant Species Exposed:	94

Figure F-44
Statewide Flood Hazard Exposure Summary for the Tulare Lake Hydrologic Region 100-year Floodplain

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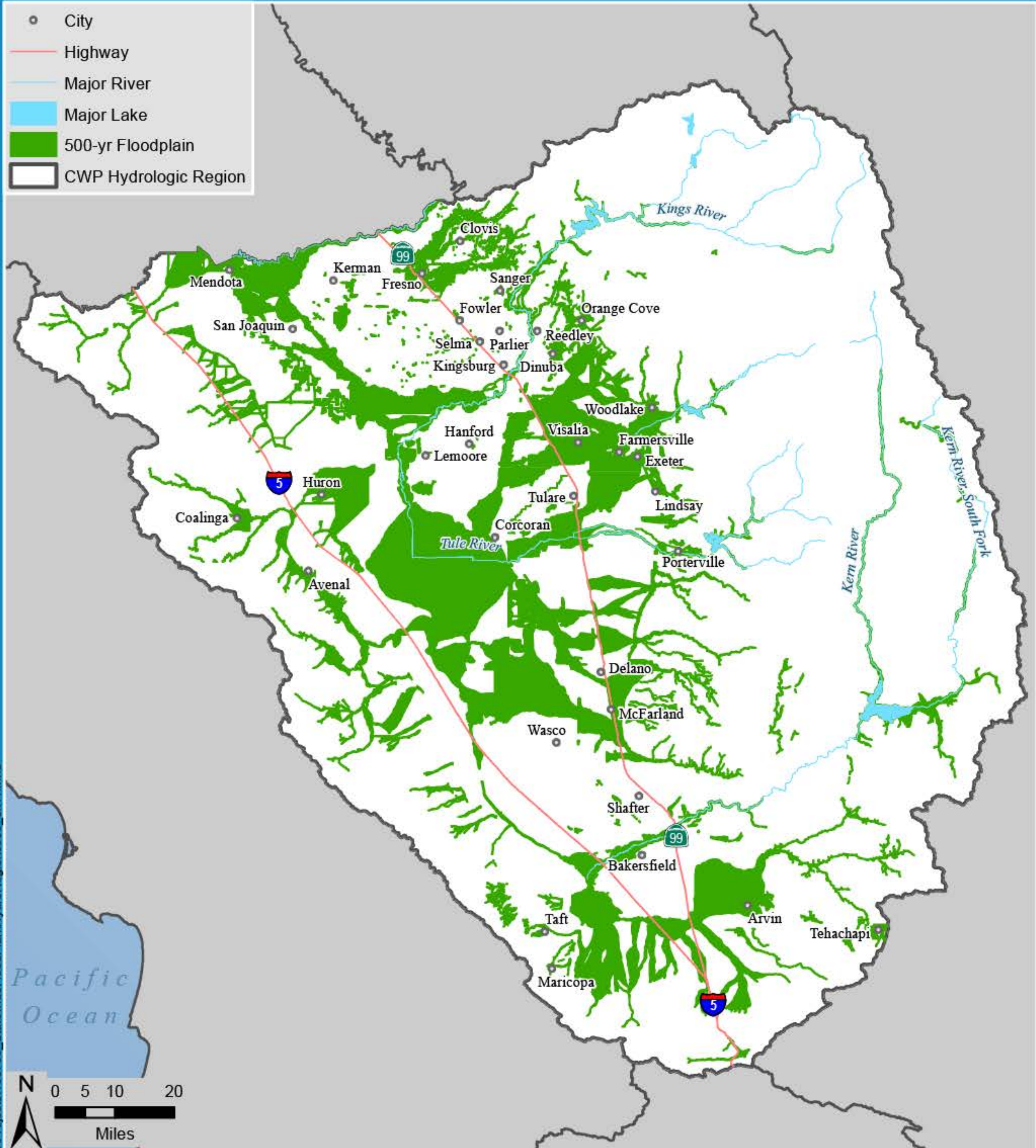

Tulare Lake Key Results

Total Population:	1,870,500	Transportation Facilities:	808
Population Exposed:	498,200	Transportation Segments (miles):	744
Percent of Population Exposed:	27	Essential Facilities:	254
Exposed Structures:	152,200	Lifeline Utilities:	25
Value of Exposed Structure and Contents:	$32.0 Billion	Dept. of Defense Facilities:	7
Total Area (acres)	10.8 Million	Dept. of Defense Facilities (acres):	25,396
Exposed Area (acres)	1,491,800	High Potential Loss Facilities:	71
Percent of Area Exposed:	14	Native American Tribes:	2
Exposed Ag.Crops (acres):	990,800	Native American Tribal Lands (acres):	109
Percent of Ag. Crops Exposed:	29	Sensitive Animal Species Exposed:	103
Value of Exposed Ag. Crops:	$2.3 Billion	Sensitive Plant Species Exposed:	94

Figure F-45
Statewide Flood Hazard Exposure Summary for the Tulare Lake Hydrologic Region 500-year Floodplain

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4.2.10 North Lahontan Hydrologic Region

Physical Setting

The North Lahontan Hydrologic Region encompasses approximately 6,110 square miles along a narrow strip of land on the eastern side of California, stretching from the Oregon border southward to the Lassen area. The region includes the Sierra Nevada mountain range and the Modoc Plateau. Much of the southern portion of the region is Federally owned and managed as national forest lands. Major lakes and reservoirs include Lake Tahoe, Honey Lake, Eagle Lake, and Upper Lake. Major streams and rivers include Truckee, Carson, and Walker rivers. Major cities include Susanville, Lake Tahoe City, and Truckee.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash

Other possible flood types:

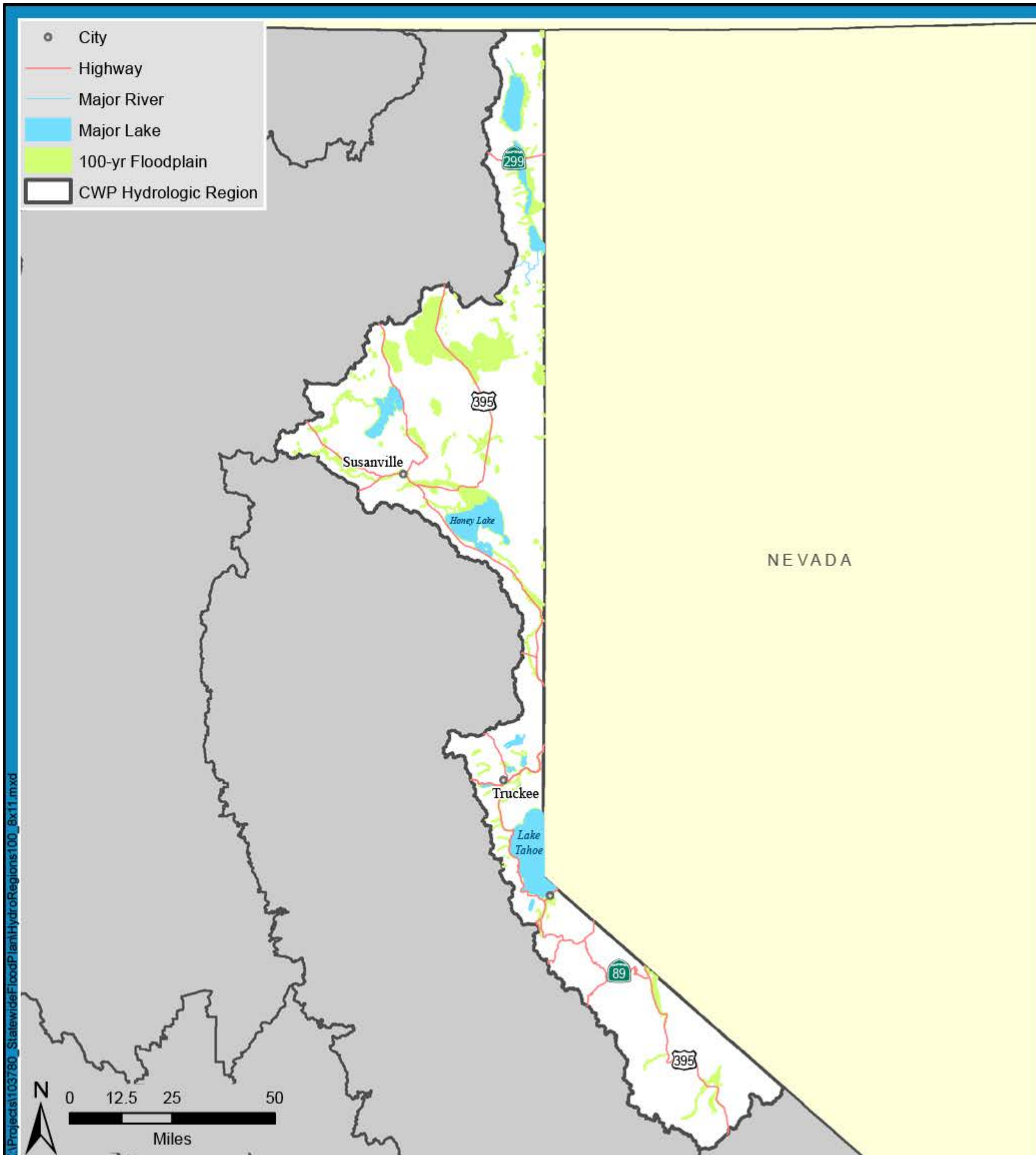
- ✓ Debris flow
- ✓ Alluvial fan
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, and flash flooding. Other possible flood types include debris flow, alluvial fan, and engineered structure failure.

Description of Exposure to Flood Hazard Results

Figures F-46 and F-47 depict the 100-year and 500-year floodplains in the North Lahontan Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. About 3,600 people and 43,000 acres of agricultural crops are exposed in the 100-year floodplain, with about 4,000 people and 43,000 acres of agricultural crops exposed in the 500-year floodplain. More than 60 sensitive plant species and 40 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 80 facilities are exposed in the 100-year floodplain, and 90 facilities are exposed in the 500-year floodplain. One Native American tribal land is exposed to the 100-year floodplain, and two Tribal lands are exposed to the 500-year floodplain.



North Lahontan Key Results

Total Population:	97,800	Transportation Facilities:	70
Population Exposed:	3,600	Transportation Segments (miles):	94
Percent of Population Exposed:	4	Essential Facilities:	3
Exposed Structures:	3,200	Lifeline Utilities:	2
Value of Exposed Structure and Contents:	$714.2 Million	Dept. of Defense Facilities:	1
Total Area (acres)	3.9 Million	Dept. of Defense Facilities (acres):	56,674
Exposed Area (acres)	487,400	High Potential Loss Facilities:	9
Percent of Area Exposed:	12	Native American Tribes:	1
Exposed Ag.Crops (acres):	42,900	Native American Tribal Lands (acres):	9
Percent of Ag. Crops Exposed:	27	Sensitive Animal Species Exposed:	46
Value of Exposed Ag. Crops:	$9.9 Million	Sensitive Plant Species Exposed:	68

Figure F-46
Statewide Flood Hazard Exposure Summary for the North Lahontan Hydrologic Region 100-year Floodplain

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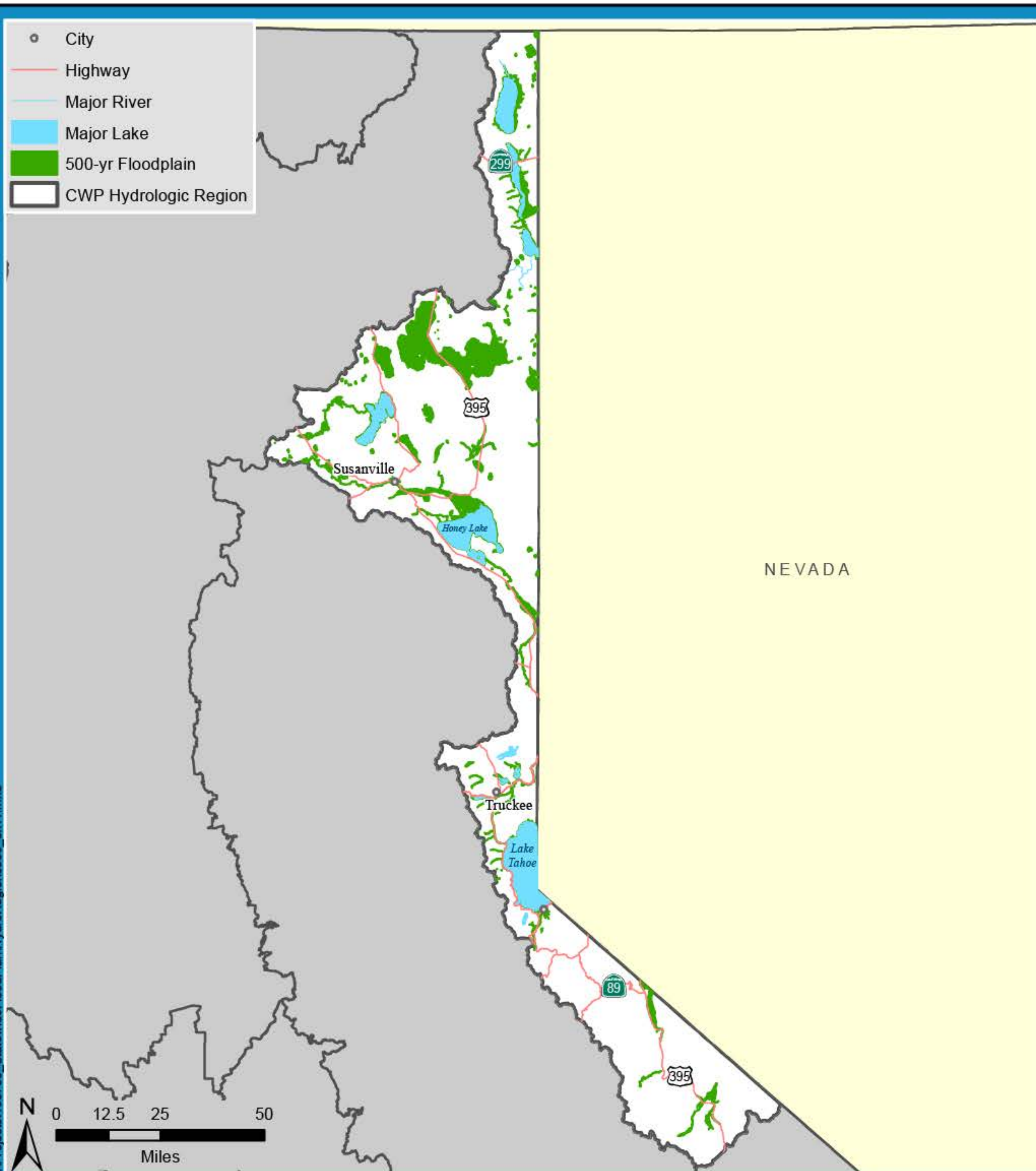

North Lahontan Key Results

Total Population:	97,800	Transportation Facilities:	75
Population Exposed:	4,000	Transportation Segments (miles):	96
Percent of Population Exposed:	4	Essential Facilities:	3
Exposed Structures:	3,500	Lifeline Utilities:	2
Value of Exposed Structure and Contents:	$823.0 Million	Dept. of Defense Facilities:	1
		Dept. of Defense Facilities (acres):	56,674
Total Area (acres)	3.9 Million	High Potential Loss Facilities:	9
Exposed Area (acres)	488,400	Native American Tribes:	2
Percent of Area Exposed:	12	Native American Tribal Lands (acres):	14
Exposed Ag.Crops (acres):	43,200	Sensitive Animal Species Exposed:	46
Percent of Ag. Crops Exposed:	27	Sensitive Plant Species Exposed:	68
Value of Exposed Ag. Crops:	$10.0 Million		

Figure F-47
Statewide Flood Hazard Exposure Summary for the North Lahontan Hydrologic Region 500-year Floodplain

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4.2.11 South Lahontan Hydrologic Region

Physical Setting

The South Lahontan Hydrologic Region covers approximately 33,100 square miles in eastern California from Mono Lake to the San Gabriel Mountains, reaching westward to the crest of the southern Sierra Nevada Mountains. The South Lahontan region includes both the highest (Mount Whitney) and lowest (Death Valley) surface elevations in the contiguous United States. Topographic features include Owens Valley, Death Valley, and Mount Whitney. The region includes many dry lakebeds and drainage sinks. Major lakes and reservoirs include Mono, June, Convict, Crawley, and Tinemaha lakes in the north, and Lake Arrowhead, Silverwood Lake, and Lake Palmdale in the south. Major streams and rivers include Owens, Mojave, and Amargosa rivers (the Amargosa River contains water only during flash floods). Major cities include Lancaster, Palmdale, Hesperia, Victorville, Apple Valley, Lake Arrowhead, and Independence.

Common flood types:

- ✓ Stormwater
- ✓ Flash
- ✓ Debris flow
- ✓ Alluvial fan

Other possible flood types:

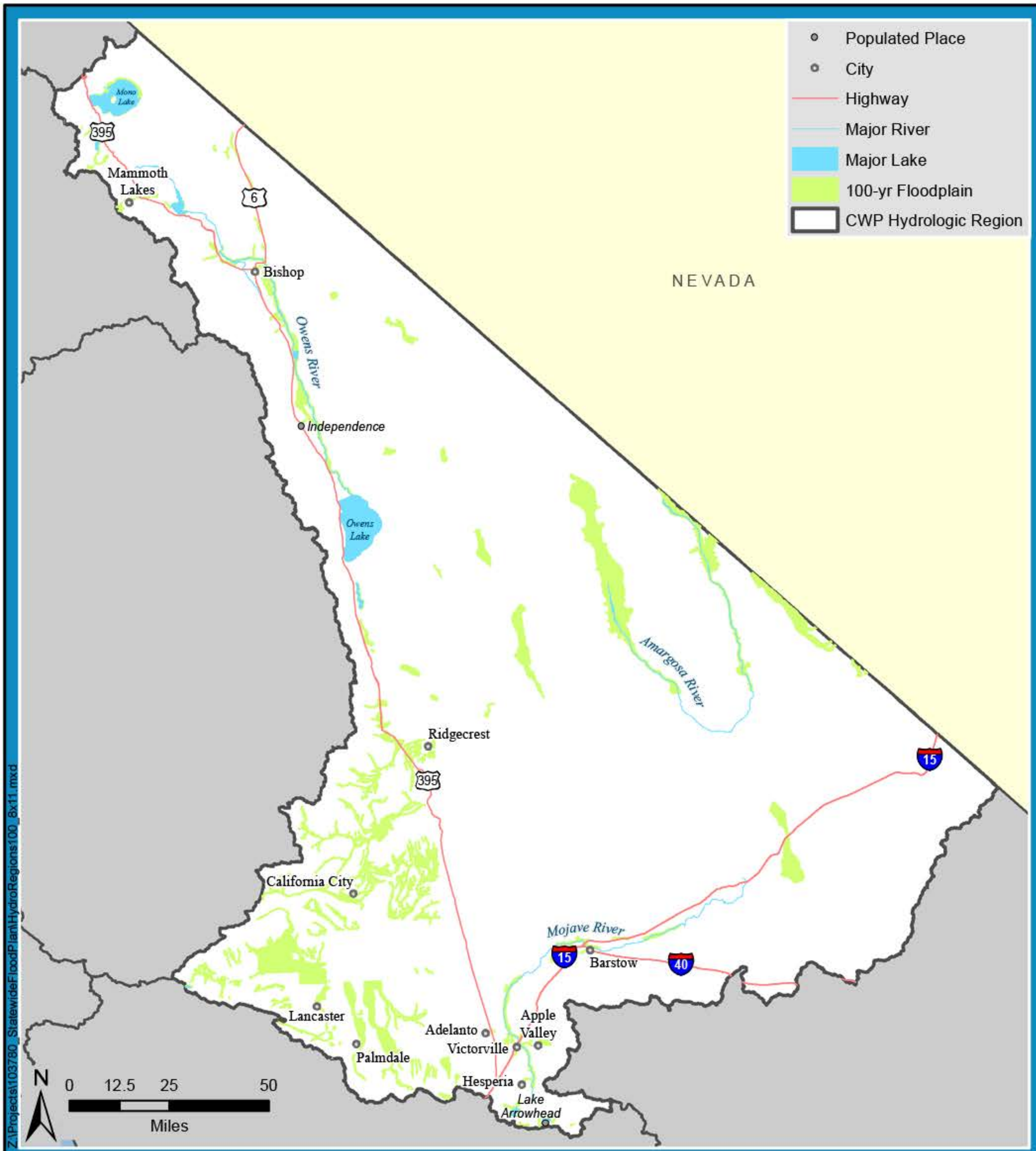
- ✓ Slow rise
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, flash, debris flow, and alluvial fan flooding. Other possible flood types include slow rise and engineered structure failure flooding. In the South Lahontan region, winter storms generally create the greatest flood damage. Storms tend to be intense. Most streams in the region are intermittent in their lower reaches, which have steeply sloped channel beds and little vegetation. Sediment loads are often dominated by coarse-grained materials. These conditions often result in flash floods and dangerous debris flows. Severe local damage could also be sustained in summer when thunderstorms generate floods upstream of an urban development.

Description of Exposure to Flood Hazard Results

Figures F-48 and F-49 depict the 100-year and 500-year floodplains in the South Lahontan Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. About 20,000 people and more than 41,000 acres of agricultural crops are exposed in the 100-year floodplain, with approximately 153,000 people and 72,000 acres of agricultural crops exposed in the 500-year floodplain. More than 100 sensitive plant species and 110 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 90 facilities are exposed in the 100-year floodplain, and more than 190 facilities are exposed in the 500-year floodplain. One Native American tribal land is exposed to 100-year and 500-year floodplains in this region.



South Lahontan Key Results

Total Population:	715,000	Transportation Facilities:	60
Population Exposed:	19,900	Transportation Segments (miles):	169
Percent of Population Exposed:	3	Essential Facilities:	16
Exposed Structures:	9,700	Lifeline Utilities:	4
Value of Exposed Structure and Contents:	$1.7 Billion	Dept. of Defense Facilities:	4
Total Area (acres)	17.1 Million	Dept. of Defense Facilities (acres):	6,498
Exposed Area (acres)	652,400	High Potential Loss Facilities:	9
Percent of Area Exposed:	4	Native American Tribes:	1
Exposed Ag.Crops (acres):	41,400	Native American Tribal Lands (acres):	3
Percent of Ag. Crops Exposed:	16	Sensitive Animal Species Exposed:	113
Value of Exposed Ag. Crops:	$25.6 Million	Sensitive Plant Species Exposed:	100

Figure F-48

Statewide Flood Hazard Exposure Summary for the South Lahontan Hydrologic Region 100-year Floodplain

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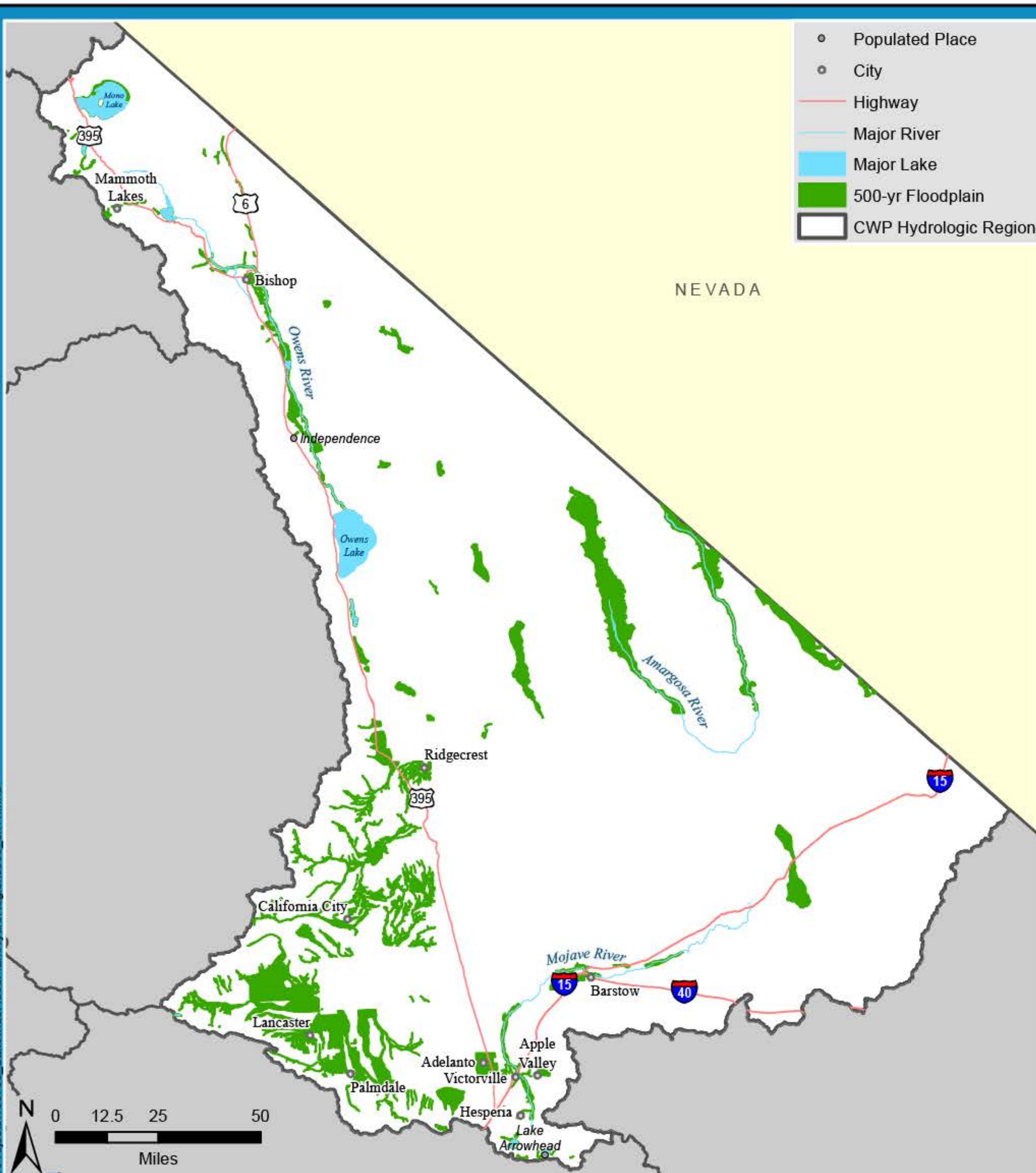

South Lahontan Key Results

Total Population:	715,100	Transportation Facilities:	94
Population Exposed:	153,200	Transportation Segments (miles):	295
Percent of Population Exposed:	21	Essential Facilities:	77
Exposed Structures:	57,200	Lifeline Utilities:	8
Value of Exposed Structure and Contents:	$11.9 Billion	Dept. of Defense Facilities:	4
Total Area (acres)	17.1 Million	Dept. of Defense Facilities (acres):	9,377
Exposed Area (acres)	820,300	High Potential Loss Facilities:	10
Percent of Area Exposed:	5	Native American Tribes:	1
Exposed Ag.Crops (acres):	72,200	Native American Tribal Lands (acres):	10
Percent of Ag. Crops Exposed:	28	Sensitive Animal Species Exposed:	113
Value of Exposed Ag. Crops:	$59.5 Million	Sensitive Plant Species Exposed:	104

Figure F-49
Statewide Flood Hazard Exposure Summary for the South Lahontan Hydrologic Region 500-year Floodplain

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4.2.12 Colorado River Hydrologic Region

Physical Setting

The Colorado River Hydrologic Region encompasses approximately 20,000 square miles in the southeastern corner of California. Significant physical features include volcanic craters, sand dunes, the San Andreas Fault, and the Salton Trough. The major lake is the Salton Sea. Major streams and rivers include Colorado, New, and Alamo rivers. Major cities include Palm Springs, Indio, El Centro, Calexico, Beaumont, Needles, and Blythe.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Debris flow
- ✓ Alluvial fan

Other possible flood types:

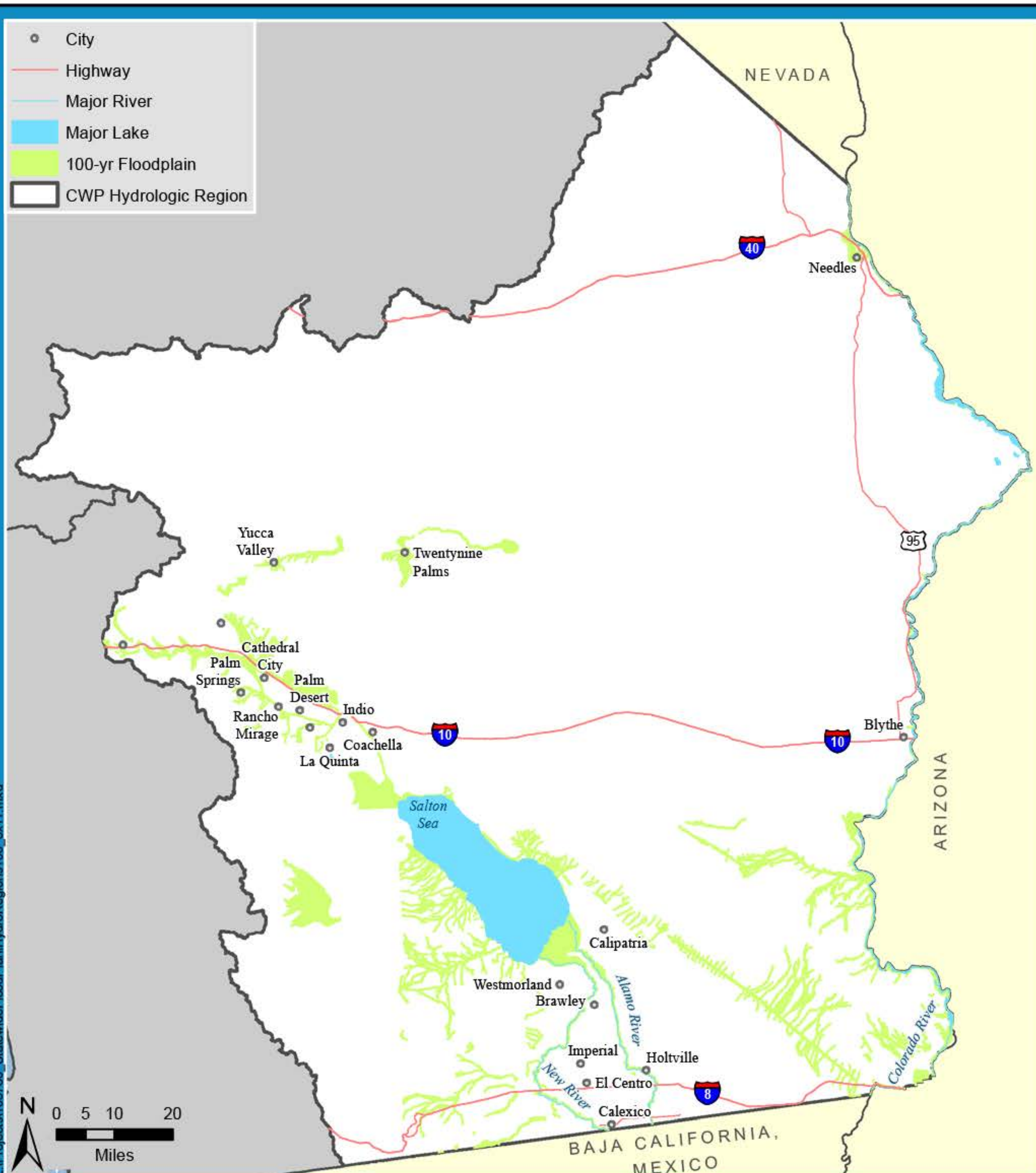
- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, debris flow, and alluvial fan flooding. Other possible flood types include engineered structure failure. Of California's hydrologic regions, the Colorado River region has the lowest annual precipitation. Consequently, most of the natural streams are ephemeral; the exceptions are the Colorado, New, and Alamo Rivers. The low annual rainfall amounts to sparse vegetation in the region's watersheds and gives rise to braided streams with steep channel slopes. In these watercourses, short-duration, high-intensity rainfall from summer monsoonal thunderstorms or winter storms can result in flash floods and debris flows.

Description of Exposure to Flood Hazard Results

Figures F-50 and F-51 depict the 100-year and 500-year floodplains in the Colorado River Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. More than 31,000 people and about 49,000 acres of agricultural crops are exposed in the 100-year floodplain, with about 227,000 people and 79,000 acres of agricultural crops exposed in the 500-year floodplain. More than 75 sensitive plant species and approximately 100 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 180 facilities are exposed in the 100-year floodplain, and more than 370 facilities are exposed in the 500-year floodplain. Nine Native American tribal lands are exposed to the 100-year floodplain, and ten Tribal lands are exposed to the 500-year floodplains.



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Colorado River Key Results

Total Population:	600,900	Transportation Facilities:	141
Population Exposed:	31,400	Transportation Segments (miles):	180
Percent of Population Exposed:	5	Essential Facilities:	20
Exposed Structures:	18,400	Lifeline Utilities:	9
Value of Exposed Structure and Contents:	$2.5 Billion	Dept. of Defense Facilities:	4
Total Area (acres)	12.7 Million	Dept. of Defense Facilities (acres):	16,962
Exposed Area (acres)	504,300	High Potential Loss Facilities:	10
Percent of Area Exposed:	4	Native American Tribes:	9
Exposed Ag.Crops (acres):	49,000	Native American Tribal Lands (acres):	29,154
Percent of Ag. Crops Exposed:	7	Sensitive Animal Species Exposed:	99
Value of Exposed Ag. Crops:	$146.1 Million	Sensitive Plant Species Exposed:	78

Figure F-50
Statewide Flood Hazard Exposure Summary for the Colorado River Hydrologic Region 100-year Floodplain

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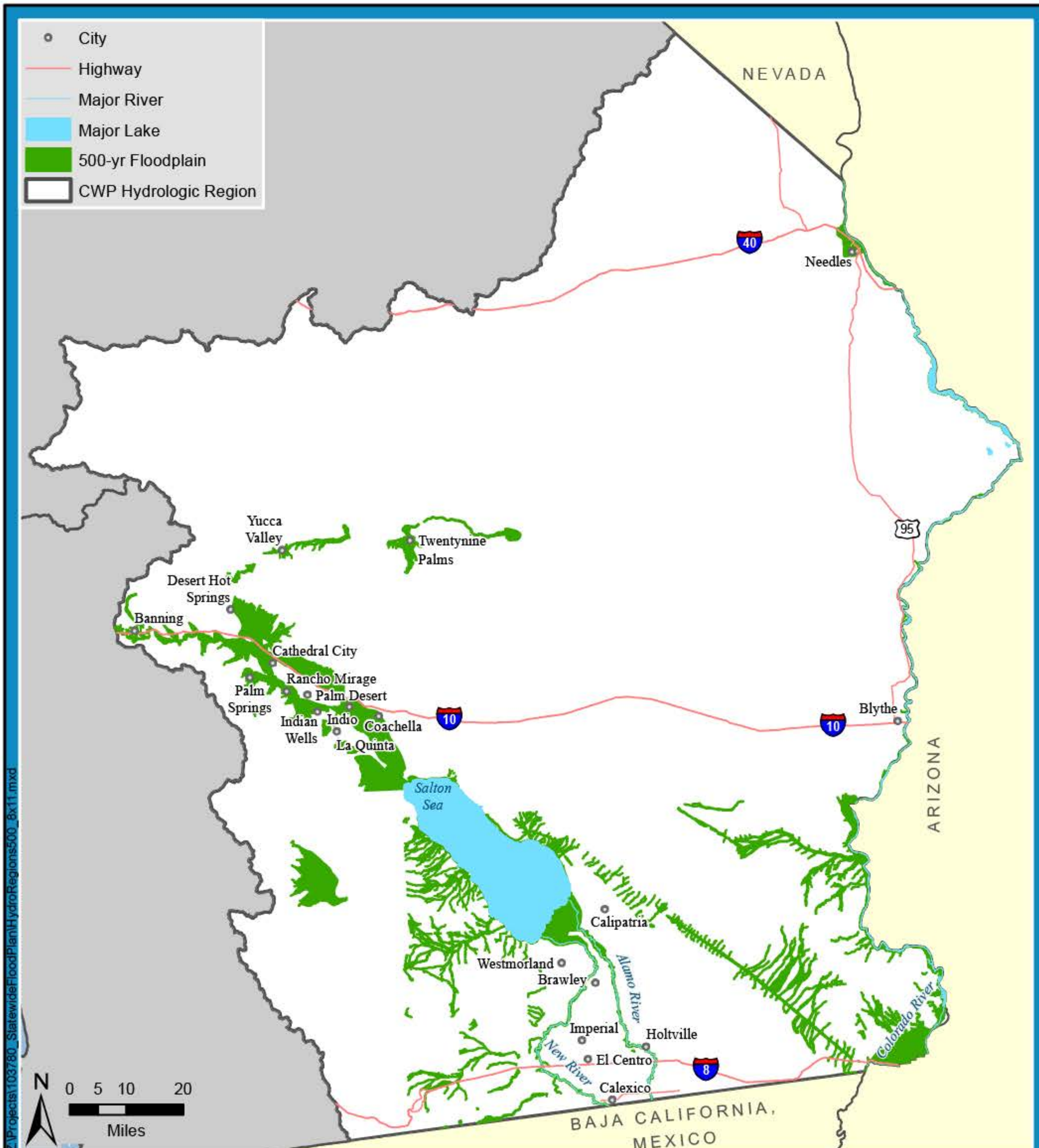

Colorado River Key Results

Total Population:	600,900	Transportation Facilities:	221
Population Exposed:	227,100	Transportation Segments (miles):	319
Percent of Population Exposed:	38	Essential Facilities:	113
Exposed Structures:	100,600	Lifeline Utilities:	22
Value of Exposed Structure and Contents:	$20.6 Billion	Dept. of Defense Facilities:	4
Total Area (acres)	12.7 Million	Dept. of Defense Facilities (acres):	16,963
Exposed Area (acres)	609,200	High Potential Loss Facilities:	15
Percent of Area Exposed:	5	Native American Tribes:	10
Exposed Ag.Crops (acres):	79,100	Native American Tribal Lands (acres):	57,499
Percent of Ag. Crops Exposed:	11	Sensitive Animal Species Exposed:	101
Value of Exposed Ag. Crops:	$275.7 Million	Sensitive Plant Species Exposed:	85

Figure F-51
Statewide Flood Hazard Exposure Summary for the Colorado River Hydrologic Region 500-year Floodplain

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4.2.13 Sacramento-San Joaquin Delta Overlay Region

Physical Setting

The Sacramento-San Joaquin Delta Overlay Region and the Suisan Marsh area are at the confluence of the Sacramento River and San Joaquin River basins, which drain about 40 percent of California. The Delta covers about 1,315 square miles in portions of six California counties and is part of the largest estuary on the West Coast of the United States. The Delta watershed covers 40 percent of the state. Many of California's major rivers converge on the Delta as tributaries of the Sacramento River, which is the state's largest river, or of the San Joaquin River. Entering the Delta separately are the Cosumnes, Mokelumne, and Calaveras rivers, the Yolo Bypass, and numerous smaller creeks and sloughs. The Delta includes portions of Contra Costa, Sacramento, San Joaquin, Solano, Yolo, and Alameda counties.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Coastal

Other possible flood types:

- ✓ Tsunami
- ✓ Engineered structure failure

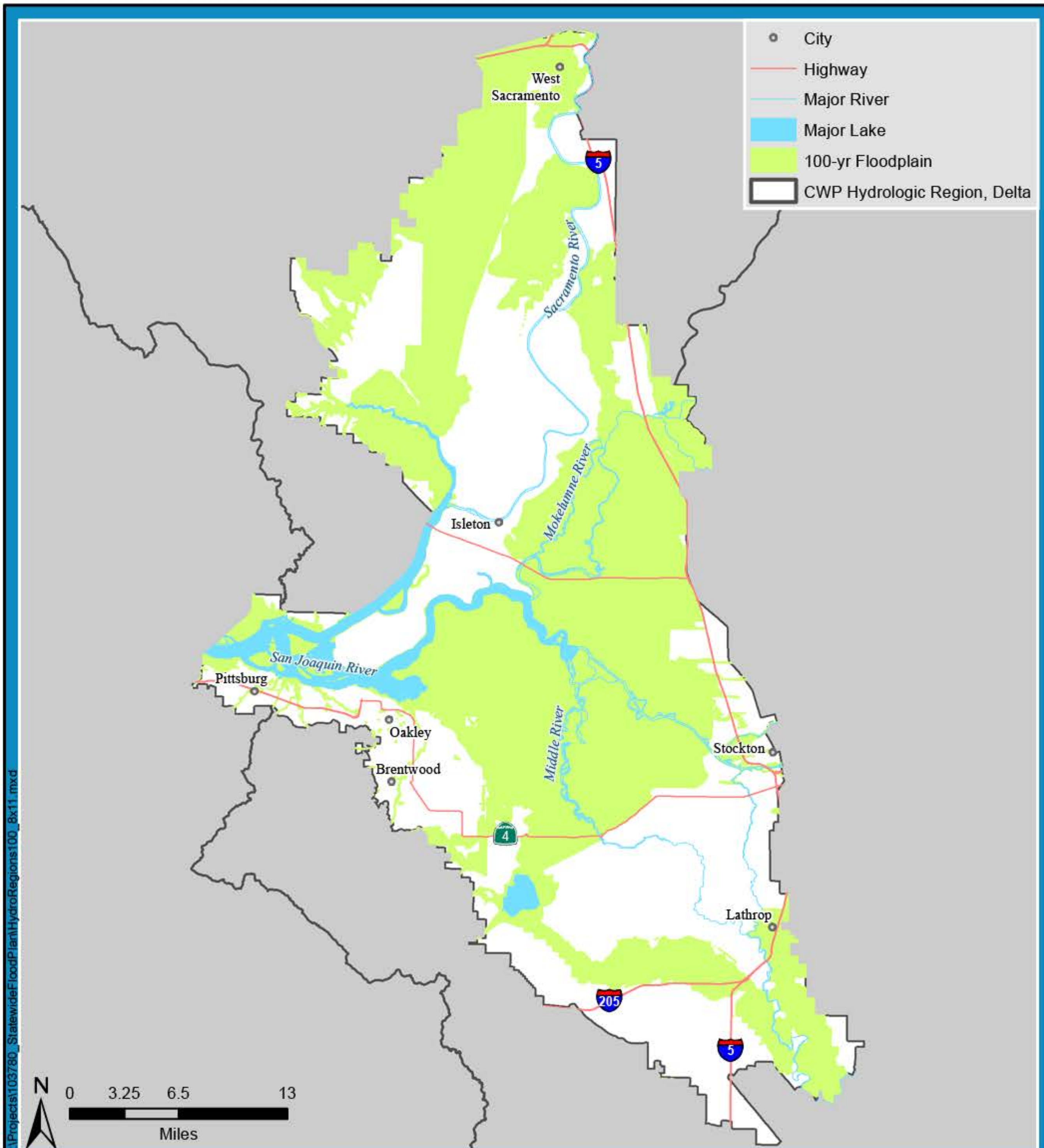
Flood Hazards

Common flood types include stormwater, slow rise, and coastal flooding. Other possible flood types include tsunami and engineered structure failure. Throughout the Delta, levees were originally constructed from material dredged from adjacent channels, but since have been improved in various places to hold back river and tidal waters. These levees are subject to damage from rodents, piping, and possibly, foundation movement. These effects may lead to sudden failure at any time of the year.

Most of the region's precipitation falls from December through March. Monthly rainfall can come all at once in 1 day during winter storms. Winter storms bring both high inflows and windy conditions. In combination with annual and daily high tides, this could cause waves to wash over and damage Delta levees, potentially leading to failure. When an island floods, the fetch (the distance along open water or land over which the wind blows, or the distance waves can traverse unobstructed) is increased to the full width of the island. The waves could cause extensive damage to unprotected interior levee slopes.

Description of Exposure to Flood Hazard Results

Figures F-52 and F-53 depict the 100-year and 500-year floodplains in the Sacramento-San Joaquin Delta Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. More than 59,000 people and about 249,000 acres of agricultural crops are exposed in the 100-year floodplain, with more than 218,000 people and more than 383,000 acres of agricultural crops exposed in the 500-year floodplain. More than 40 sensitive plant species and 60 sensitive animal species are exposed in the 100-year and 500-year floodplains. About 180 facilities are exposed in the 100-year floodplain, and more than 400 facilities are exposed in the 500-year floodplain. No Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.



Delta Key Results

Total Population:	461,800	Transportation Facilities:	134
Population Exposed:	59,300	Transportation Segments (miles):	135
Percent of Population Exposed:	13	Essential Facilities:	20
Exposed Structures:	23,800	Lifeline Utilities:	4
Value of Exposed Structure and Contents:	$6.1 Billion	Dept. of Defense Facilities:	2
Total Area (acres)	737,700	Dept. of Defense Facilities (acres):	34
Exposed Area (acres)	389,000	High Potential Loss Facilities:	19
Percent of Area Exposed:	53	Native American Tribes:	-
Exposed Ag.Crops (acres):	248,900	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	51	Sensitive Animal Species Exposed:	61
Value of Exposed Ag. Crops:	$682.7 Million	Sensitive Plant Species Exposed:	46

Figure F-52

Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 100-year Floodplain

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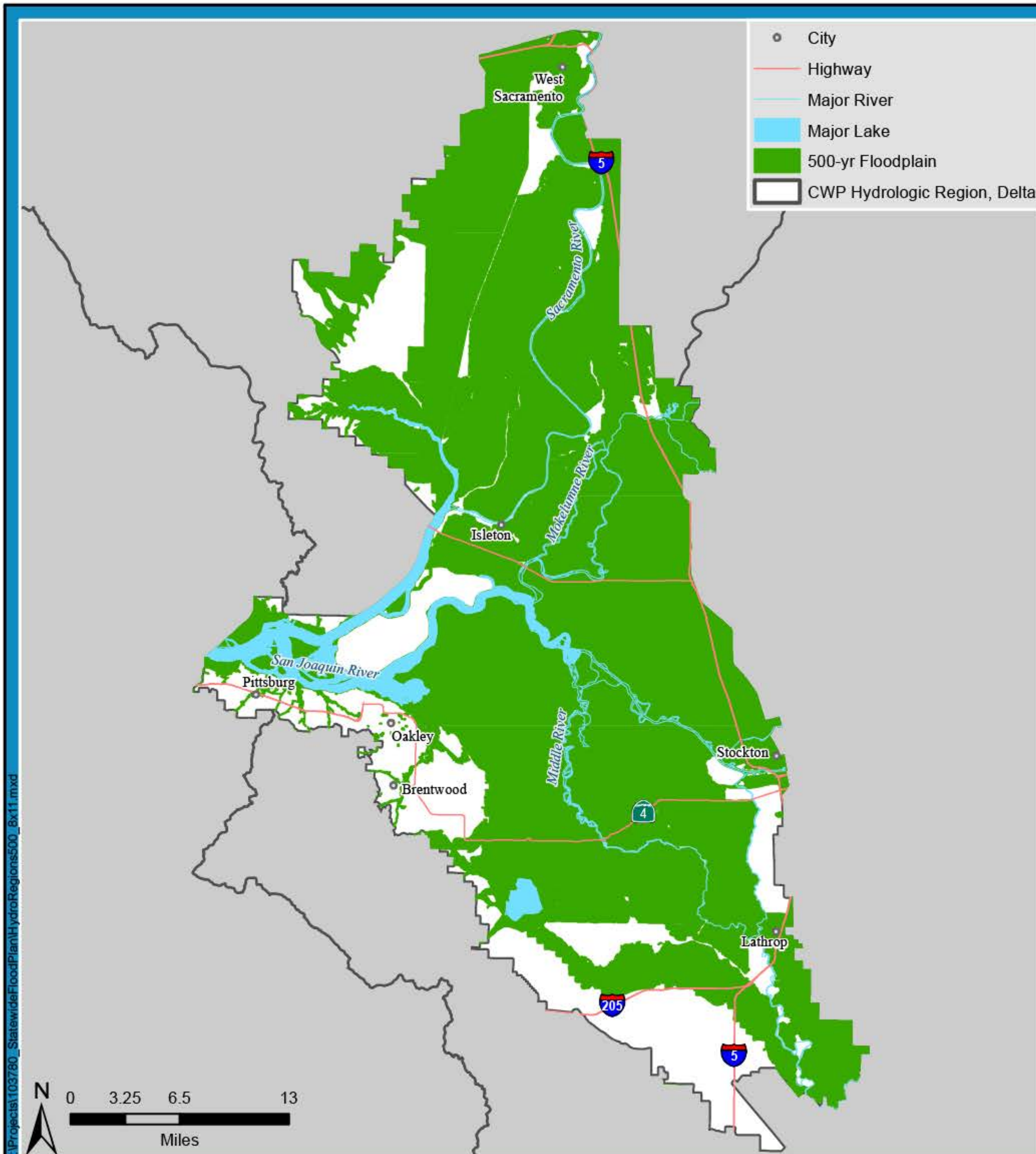
Jan 28, 2013



Delta Key Results

Total Population:	461,800	Transportation Facilities:	251
Population Exposed:	218,100	Transportation Segments (miles):	246
Percent of Population Exposed:	47	Essential Facilities:	92
Exposed Structures:	74,500	Lifeline Utilities:	13
Value of Exposed Structure and Contents:	$18.0 Billion	Dept. of Defense Facilities:	2
Total Area (acres)	737,700	Dept. of Defense Facilities (acres):	52
Exposed Area (acres)	553,100	High Potential Loss Facilities:	47
Percent of Area Exposed:	75	Native American Tribes:	-
Exposed Ag.Crops (acres):	383,000	Native American Tribal Lands (acres):	-
Percent of Ag. Crops Exposed:	78	Sensitive Animal Species Exposed:	64
Value of Exposed Ag. Crops:	$1.0 Billion	Sensitive Plant Species Exposed:	46

Figure F-53

Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 500-year Floodplain

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Jan 28, 2013

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4.2.14 Mountain Counties Overlay Region

Physical Setting

The Mountain Counties Overlay Region of California includes the foothills and mountains of the western slope of the Sierra Nevada Mountains and a portion of the Cascade Range. The area extends from the southern tip of Lassen County to the northern part of Fresno County and overlays the eastern portions of the Sacramento River and San Joaquin River hydrologic regions. The foothills and mountain areas of these two hydrologic regions are grouped together to present their common characteristics.

The region includes all or portions of 15 counties, including Plumas, Sierra, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, and Madera counties. Elevations vary from around 100 feet near the edge of the valley floor to nearly 14,000 feet at peaks along the crest of the southern Sierra Nevada. Major rivers include the Feather, Yuba, Bear, and American rivers in the Sacramento River Hydrologic Region and the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and San Joaquin rivers in the San Joaquin River Hydrologic Region. These watersheds account for about a quarter of all natural river runoff in California and over half of all snowmelt runoff in the state.

Common flood types:

- ✓ Stormwater
- ✓ Slow rise
- ✓ Flash
- ✓ Debris flow

Other possible flood types:

- ✓ Engineered structure failure

Flood Hazards

Common flood types include stormwater, slow rise, flash, and debris flow flooding. Other possible flood types include engineered structure failure. Floodwaters in the region originate from rainfall or melting of the Sierra Nevada snowpack. Floods are often of short duration, but due to the steep stream gradients, they can be destructive. Towns and roads along major streams at the bottom of canyons are especially vulnerable.

Description of Exposure to Flood Hazard Results

Figures F-54 and F-55 depict the 100-year and 500-year floodplains in the Mountain Counties Hydrologic Region, as well as key results for the exposure to flood hazard analysis within the hydrologic region for each floodplain. Over 11,000 people and 30,000 acres of agricultural crops are exposed in the 100-year floodplain, with over 13,000 people and 31,000 acres of agricultural crops exposed in the 500-year floodplain. More than 120 sensitive plant species and 80 sensitive animal species are exposed in the 100-year and 500-year floodplains. More than 220 facilities are exposed in the 100-year floodplain, and more than 230 facilities are exposed in the 500-year floodplain. Two Native American tribal lands are exposed to 100-year and 500-year floodplains in this region.

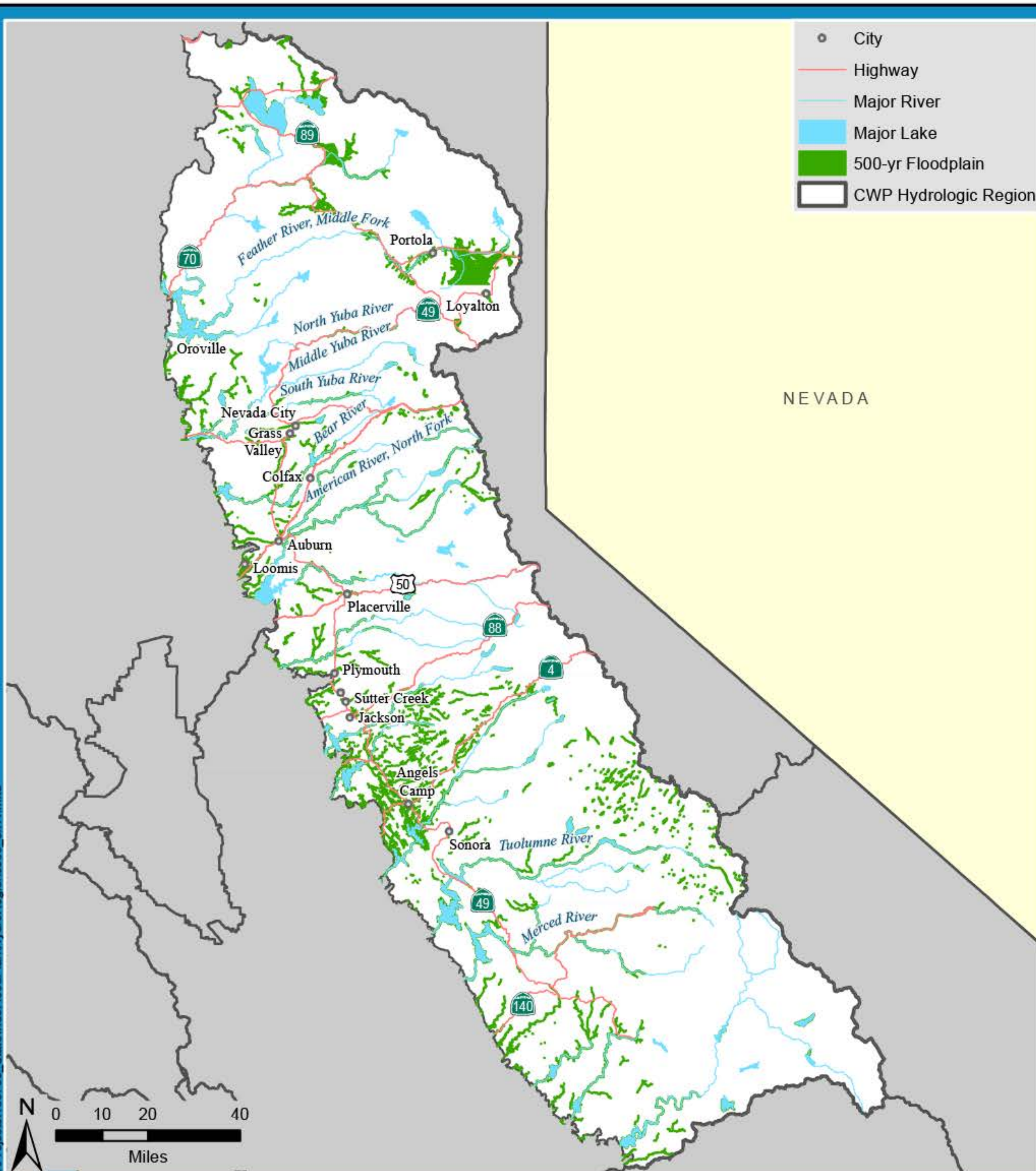
Mountain Counties Key Results

Total Population:	540,400	Transportation Facilities:	141
Population Exposed:	11,300	Transportation Segments (miles):	81
Percent of Population Exposed:	2	Essential Facilities:	14
Exposed Structures:	6,000	Lifeline Utilities:	1
Value of Exposed Structure and Contents:	$1.4 Billion	Dept. of Defense Facilities:	-
Total Area (acres)	10.1 Million	Dept. of Defense Facilities (acres):	-
Exposed Area (acres)	268,400	High Potential Loss Facilities:	70
Percent of Area Exposed:	3	Native American Tribes:	2
Exposed Ag.Crops (acres):	30,200	Native American Tribal Lands (acres):	412
Percent of Ag. Crops Exposed:	20	Sensitive Animal Species Exposed:	87
Value of Exposed Ag. Crops:	$1.4 Million	Sensitive Plant Species Exposed:	123

Figure F-54
Statewide Flood Hazard Exposure Summary for the Mountain Counties Region 100-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA



Mountain Counties Key Results

Total Population:	540,400	Transportation Facilities:	147
Population Exposed:	13,600	Transportation Segments (miles):	86
Percent of Population Exposed:	3	Essential Facilities:	18
Exposed Structures:	7,200	Lifeline Utilities:	1
Value of Exposed Structure and Contents:	$1.6 Billion	Dept. of Defense Facilities:	-
Total Area (acres)	10.1 Million	Dept. of Defense Facilities (acres):	-
Exposed Area (acres)	270,300	High Potential Loss Facilities:	70
Percent of Area Exposed:	3	Native American Tribes:	2
Exposed Ag.Crops (acres):	30,900	Native American Tribal Lands (acres):	412
Percent of Ag. Crops Exposed:	20	Sensitive Animal Species Exposed:	87
Value of Exposed Ag. Crops:	$1.4 Million	Sensitive Plant Species Exposed:	123

Figure F-55

Statewide Flood Hazard Exposure Summary for the Mountain Counties Region 500-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

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5.0 Future Impacts on Exposure to Flood Hazard

This section provides a qualitative discussion of future impacts on exposure to flood hazard, which could increase or decrease as a result from changes in population, growth patterns, land use, or climate. Flood exposure in California is dynamic because these influencing factors are constantly changing.

5.1 How Population, Growth Patterns, and Land Use Changes Impact the Flood Hazard Exposure Analysis

Population increase and growth patterns could add to the number of people, amount of property, and infrastructure exposed to flood hazards. New development that is required to accommodate population growth could occur within existing floodplains near creeks, streams, the coast, or other bodies of water, thus increasing exposure to flood hazards. For example, in portions of Sacramento, Stockton, Marysville, and Yuba City, new developments have often been constructed in areas subject to flooding, with protection provided by flood management measures put in place (e.g., levees). Although flood management measures provide a certain level of protection, new development in the floodplain still exposes additional people to potential flood hazards.

Future conditions, including increases in population and changes in growth patterns, are likely to lead to a greater number of people and amount of property exposed to flood hazards.

As noted in Section 2 of this attachment, the flood hazard exposure analysis used year 2000 population data to estimate the number of people exposed to the 100-year and 500-year floodplain. However, between 2000 and 2010, California's population increased by about 10 percent from 33.9 million to 37.3 million, which has likely resulted in greater exposure to flooding.

Table F-15 shows the increase in population from 2000 to 2010 in each county. Riverside and Placer counties experienced the greatest growth rates in the state, with increases of more than 40 percent. Nine counties (Riverside, Placer, Kern, Imperial, Madera, Tulare, San Joaquin, Merced, and Sutter) had population increases of more than 20 percent between 2000 and 2010. The four counties with the greatest exposure to flood hazards using the 2000 population data (Orange, Santa Clara, San Mateo, and Los Angeles) each had less than 6 percent growth between 2000 and 2010.

Table F-15. Change in Population in Each County from 2000 to 2010

County	2000	2010	% Change
Alameda	1,443,547	1,510,271	4.6
Alpine	1,210	1,175	-2.9
Amador	35,100	38,091	8.5
Butte	203,166	220,000	8.3
Calaveras	40,552	45,578	12.4
Colusa	18,804	21,419	13.9
Contra Costa	949,049	1,049,025	10.5
Del Norte	27,471	28,610	4.1
El Dorado	156,255	181,058	15.9
Fresno	798,799	930,450	16.5
Glenn	26,448	28,122	6.3
Humboldt	126,477	134,623	6.4
Imperial	142,359	174,528	22.6
Inyo	17,944	18,546	3.4
Kern	661,591	839,631	26.9
Kings	129,475	152,982	18.2
Lake	58,308	64,665	10.9
Lassen	33,828	34,895	3.2
Los Angeles	9,515,955	9,818,605	3.2
Madera	123,106	150,865	22.5
Marin	247,239	252,409	2.1
Mariposa	17,140	18,251	6.5
Mendocino	86,198	87,841	1.9
Merced	211,108	255,793	21.2
Modoc	9,445	9,686	2.6
Mono	12,851	14,202	10.5
Monterey	401,683	415,057	3.3
Napa	124,232	136,484	9.9
Nevada	92,066	98,764	7.3
Orange	2,843,086	3,010,232	5.9
Placer	248,254	348,432	40.4
Plumas	20,828	20,007	-3.9
Riverside	1,545,114	2,189,641	41.7
Sacramento	1,223,622	1,418,788	15.9
San Benito	53,194	55,269	3.9
San Bernardino	1,709,927	2,035,210	19.0
San Diego	2,811,030	3,095,313	10.1
San Francisco	776,637	805,235	3.7
San Joaquin	563,610	685,306	21.6
San Luis Obispo	246,652	269,637	9.3
San Mateo	706,815	718,451	1.6
Santa Barbara	398,960	423,895	6.2
Santa Clara	1,682,689	1,781,642	5.9

Table F-15. Change in Population in Each County from 2000 to 2010

County	2000	2010	% Change
Santa Cruz	255,435	262,382	2.7
Shasta	163,241	177,223	8.6
Sierra	3,556	3,240	-8.9
Siskiyou	44,307	44,900	1.3
Solano	395,264	413,344	4.6
Sonoma	458,520	483,878	5.5
Stanislaus	447,034	514,453	15.1
Sutter	78,927	94,737	20.0
Tehama	56,050	63,463	13.2
Trinity	13,021	13,786	5.9
Tulare	368,064	442,179	20.1
Tuolumne	54,508	55,365	1.6
Ventura	753,402	823,318	9.3
Yolo	168,013	200,849	19.5
Yuba	60,223	72,155	19.8
Total	33,861,390	37,253,956	10.0

Source: DOF, 2013

California's population is expected to continue to increase in the future. In the Central Valley, State law requires that new development in urban and urbanizing areas comply with requirements for a 200-year level (0.5 percent annual chance) of protection after 2015. There are no similar requirements for development outside the Central Valley. However, even when the level of flood protection is significantly improved (e.g., where a 200-year level of protection is required), exposure to flood hazard can increase simply by putting more people, property, and infrastructure in the floodplain.

As California's population increases in the future and urban development further encroaches on agricultural land areas, the estimated exposure of population and urban property to the 100-year and 500-year floodplains can be expected to increase in many parts of the state while the exposure of agricultural crops would decrease. The conversion of agricultural land to urban uses could also cause an increase in local runoff, thereby causing a shift in the extents of the 100-year and 500-year floodplains. The magnitude of impact that these changes would have on flood hazard exposure would depend on the rate of population increase and corresponding urban encroachment on agricultural land areas, which cannot be predicted with certainty. In order to depict a range of future uncertainty in future population and land use, the CWP Update 2009 (DWR, 2009b) has identified the following three future scenarios through the year 2050:

- Scenario 1 – Current Trends: Assumes that recent trends continue into the future. Under this scenario, urban flood hazard exposure would increase and agricultural flood hazard exposure would decrease, compared to current conditions.

- Scenario 2 – Slow and Strategic Growth: Assumes more efficient planning and development that is less resource intensive than current conditions. Urban development is more compact, and less agricultural land is converted to urban uses than in the Current Trends scenario. Therefore, future urban flood hazard exposure would be expected to be less and future agricultural flood hazard exposure would be expected to be greater than in the Current Trends scenario.
- Scenario 3 – Expansive Growth: Assumes that future development is more resource intensive than current conditions. Urban development is less dense and urban areas are expanding resulting in a more aggressive conversion from other land uses (e.g., agriculture, open space) than in the Current Trends scenario. Therefore, future urban flood hazard exposure would be expected to be greater and future agricultural flood hazard exposure would be expected to be less than in the Current Trends scenario.

The CWP has projected future population growth in each CWP hydrologic region through 2050 for each scenario. These projections are shown in Table F-16. In the three scenarios, the greatest growth is projected to occur in the San Joaquin, Tulare Lake, South Lahontan, and Colorado River regions.

Table F-16. Projected Change in Population in Each Hydrologic Region from 2000 to 2050 for each CWP Scenario

CWP Hydrologic Region	2000 Population	California Water Plan Scenario					
		Slow and Strategic Growth		Current Trends		Expansive Growth	
		2050 Population	% Change	2050 Population	% Change	2050 Population	% Change
North Coast Region	640,000	780,000	21.9	1,030,000	60.9	1,190,000	85.9
San Francisco Bay Region	6,070,000	6,140,000	1.2	8,950,000	47.4	11,020,000	81.5
Central Coast Region	1,450,000	1,660,000	14.5	2,150,000	48.3	2,720,000	87.6
South Coast Region	18,070,000	21,530,000	18.8	27,110,000	49.6	32,130,000	77.3
Sacramento River Region	2,570,000	3,970,000	54.5	5,350,000	108.2	5,920,000	130.4
San Joaquin River Region	1,750,000	3,460,000	97.7	4,890,000	179.4	5,180,000	196.0
Tulare Lake Region	1,870,000	3,580,000	91.4	5,190,000	177.5	5,530,000	195.7
North Lahontan Region	100,000	130,000	30.0	150,000	50.0	170,000	70.0
South Lahontan Region	720,000	1,360,000	88.9	2,390,000	231.9	3,380,000	369.4
Colorado River Region	600,000	1,590,000	165.0	2,310,000	285.0	2,570,000	328.3
Total	33,820,000	44,200,000	30.5	59,510,000	75.7	69,800,000	106.1

Source: DWR, 2009b

5.2 How Climate Change Impacts the Flood Hazard Exposure Analysis

Climate change could have a significant impact on the timing and magnitude of runoff in California. In addition, increasing temperatures could result in a rise in sea level due to the melting of land-based glaciers, snowfields and ice sheets, along with thermal expansion of the ocean as the surface layer warms (DWR, 2008). These changes could result in expansions of the 100-year and 500-year floodplains, thereby causing an increase in the people, property, and infrastructure exposed to flood hazards in the future. The potential future climate change effects on precipitation and runoff patterns and on sea level rise, including the effect that these changes might have on flood hazard exposure, are described in the following sections.

5.2.1 Changes in Precipitation and Runoff Patterns

Climate change is projected to cause increases in global temperatures that will likely lead to shifts in the timing and magnitude of precipitation and runoff in California. Researchers suggest that, although the total volume of precipitation is not likely to change significantly during the next several decades, the seasonal timing of the precipitation might shift, which could increase flood peak flows and flood volumes (Miller et al., 2003; Fissekis, 2008; CEC, 2009a; Das et al., 2011). Increased temperature may alter precipitation and runoff patterns, resulting in higher snowline elevations, snowmelt occurring earlier in the year, and less overall snowpack. If precipitation events occur concurrently with warmer temperatures, more of the precipitation will fall as rain rather than snow. This would increase the extent and depth of floodplains because more watershed area contributes to direct runoff. In this case, the precipitation would flow into the watersheds instead of accumulating as snowpack, thus increasing the amount of runoff during winter months.

Figure F-56 depicts an example, as described in *Progress on Incorporating Climate Change into Management of California's Water Resources,* of how the level of precipitation during an extreme weather event could increase in the future (DWR, 2006). Figure F-56 shows the changes in runoff for an example storm on the Feather River. In this example, a 1-degree increase in future temperature results in about a 20 percent increase in peak flow, and a 5-degree increase in future temperature results in about a 130 percent increase in peak flow.

The projected temporal shift in reservoir inflows could pose significant challenges for management of flood storage capacity in major system reservoirs. Flood management space requirements are generally specified using reservoir drawdown curves as a function of accumulated snowpack forecasts, measured rainfall, and the seasonability of precipitation. Changes in precipitation form (rain rather than snow) associated with temporal shifts in runoff, along with potential increases in flood frequencies and magnitudes, are likely to require reevaluation of existing operational rules that were developed based on previously accepted historical conditions.

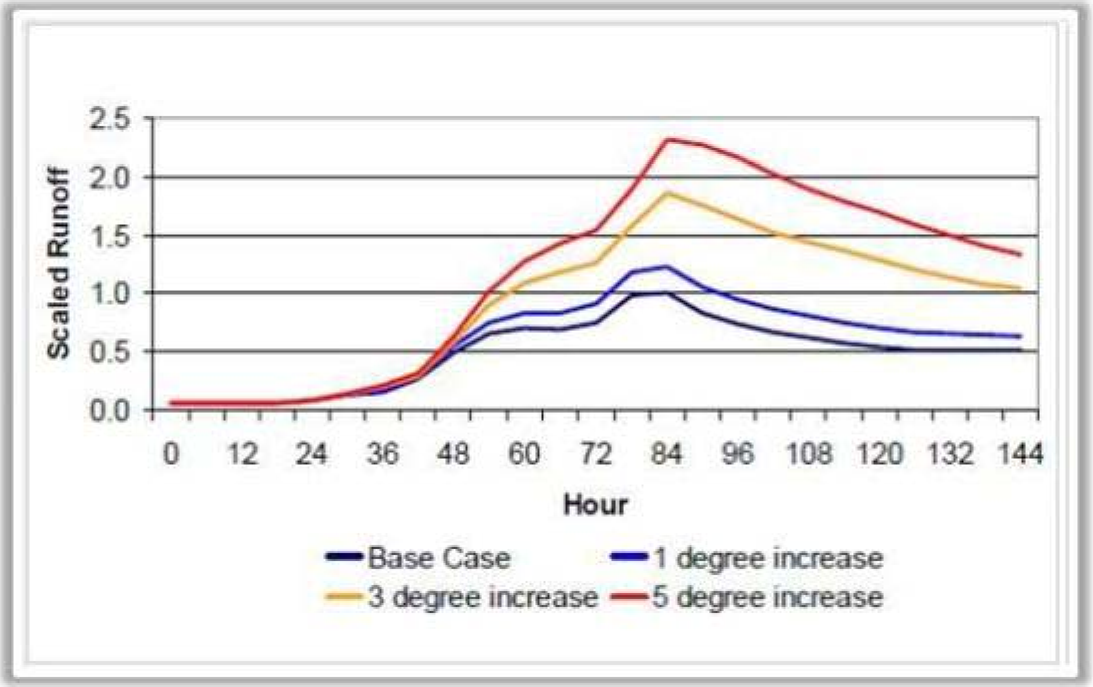

Figure F-56. Changes in Runoff for an Example under Different Climate Futures
(Source: DWR, 2006)

Flooding is a result of individual weather events that can be considered random phenomena on the scale of climate (e.g., 30 to 50 years). It can be difficult to understand how these long-term trends will affect the frequency and magnitude of flood events. From year to year, a large amount of variability exists in winter rainfall and associated runoff patterns. This variability creates uncertainty when evaluating potential changes in weather events due to climate change. Existing climate projections that are currently used for some hydrologic consequences of climate change (e.g., mean runoff change, earlier snowmelt) might not be useful for showing the consequences of short-term flood events. Flood modeling requires high-resolution (spatial and temporal) climate projections that are currently unavailable with high quality from most climate models.

Although many water resource factors are affected by average conditions, some of the most important impacts, such as flooding, will result not from changes in averages but from changes in local extremes.

Increased temperature alone might be expected to alter flooding patterns; however, changes in storm types, frequencies, or magnitudes might result in more direct impacts. Historically, the most dangerous storms in California have been extreme events (e.g., warm and wet storms that strike in winter, producing intense rains over large areas).

Therefore, climate change likely will result in more frequent extreme precipitation events. Although uncertainties remain about future changes in long-term average precipitation rates in California, it is generally expected that extreme precipitation episodes will become even more extreme as the climate changes (Dettinger, 2011). The projected increases in the frequency and magnitude of extreme storm events would result in increased exposure of population, property, and facilities to the 100-year and 500-year floodplains in many parts of the state.

Potential changes in the frequency and magnitude of extreme storm events should be accounted for in statewide and local water planning in California. The *California Climate Adaptation Planning Guide* (CalEMA and CNRA, 2011) and *Climate Change Handbook for Regional Water Planning* (EPA and DWR, 2011) provide guidance to local agencies for considering climate change in water management planning.

5.2.2 Sea Level Rise

The projected increases in future temperature also would result in sea level rise due to the melting of land-based glaciers, snowfields, and ice sheets, along with thermal expansion of the ocean as the surface layer warms (DWR, 2008). In the last century, sea level has risen about 20 centimeters (cm) (7 inches) along California's coast (DWR, 2008). Figure F-57 shows the projected range in potential sea level rise in the future.

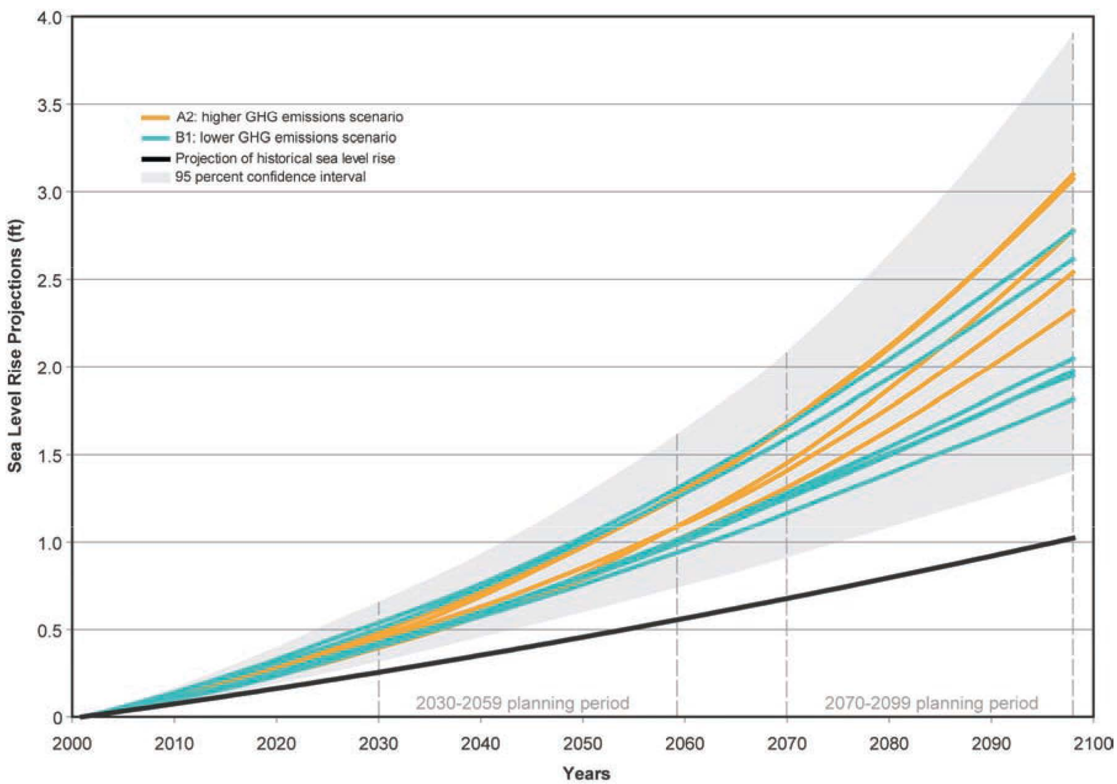

Figure F-57. Sea Level Rise Projections Based on Air Temperatures from 12 Future Climate Scenarios
(Source: CEC, 2009)

Continuation or acceleration of this sea level rise, in combination with changes in precipitation and runoff patterns, likely would result in an increase in flood events, especially in the Central Valley (Knox, 1993; Florsheim and Dettinger, 2007). In coastal areas, a rise in sea level is likely to produce more frequent and potentially more damaging floods, increasing the exposure of people, property, and infrastructure to flood hazards, not only by exacerbating existing hazards but also by increasing the size of coastal floodplains (CEC, 2009b; Knowles, 2010; Heberger et al., 2011; CEC, 2012). As an example, Figure F-58 shows the projected increase in flood inundation in the San Francisco Bay under one scenario of sea level rise. In

Figure F-58, Plot A shows areas inundated or vulnerable to inundation under 100-year high-water levels for present-day (blue) and a 150-cm sea level rise (red). Plot B shows the same areas inundated with a 150-cm sea level rise as in Plot A, but colored according to land-use type (Knowles, 2010). (Note that the inundation shown in Figure F-58 does not take into account existing flood infrastructure along the San Francisco Bay shoreline.)

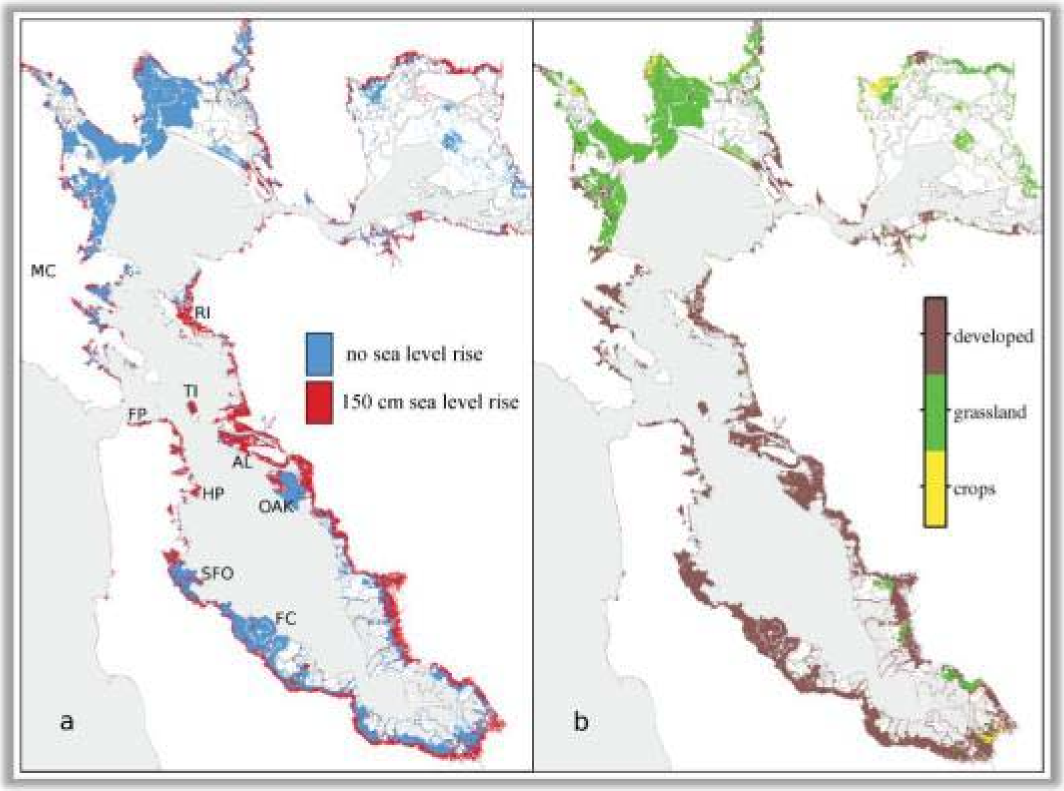

Figure F-58. Projected San Francisco Bay Flood Inundation under a 150-cm Sea Level Rise Scenario
(Source: Knowles, 2010)

The *State of California Seal Level Rise Interim Guidance Document* provides policy recommendations for incorporating sea level rise projections into planning and decision-making in California (CO-CAT 2013). This document was recently updated to incorporate the findings of the study *Sea Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future*, which was published in late 2012 (Committee on Sea Level Rise in California, Oregon, and Washington, et al., 2012). The study was developed to analyze the impacts of sea level rise on the California coast by the National Research Council, in partnership with the Committee on Sea Level Rise in California, Oregon, and Washington, the Board on Earth Sciences and Resources, and the Ocean Studies Board.

Rising sea levels are likely to have a direct effect on water levels in the Delta because most of the islands of land within the Delta are below sea level, many by as much as 20 to 25 feet. Rising sea levels will cause backwater effects upstream of the Delta. Global sea level rise, combined with short-term or episodic factors that increase sea level and water levels in the Delta, will reduce available levee freeboard unless levees are raised. Short-term and episodic increases in water levels in the Delta include high river flows, ocean/atmospheric phenomena such as El Niño, storm surges, barometric high tides, and high astronomical tides (particularly during perigee, perihelion, and either new or full moon). The impacts of sea level rise would be most significant for the Delta, where a rise in sea-level would increase hydrostatic pressure on levees currently protecting low-lying land. These effects threaten to cause potentially catastrophic levee failures that inundate communities, damage infrastructure, and interrupt water supplies throughout the state (Hanak and Lund, 2008). For example, a 1-foot rise in sea level could increase the frequency of the 100-year peak high tide to a 10-year event in the western Delta at Antioch (Roos, 2005). The resulting higher tides, in combination with increases in storm intensity and flood volumes, would likely aggravate existing flood problems in upstream areas along the Sacramento and San Joaquin rivers.

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6.0 Findings

An important objective of the SFMP Program is to characterize current and future flood risks throughout California based on the best available information. This attachment describes the flood hazard exposure analysis that was performed to provide insight into potential flood risks throughout the state. This analysis supplements the information presented in the SFMP Flood Future Report with a detailed description of the method and results of the flood hazard exposure analysis. The results of this flood hazard exposure analysis provide useful insight into the potential risks due to flooding that currently exist in California. The following are some conclusions that can be drawn from the results of the analysis:

- A significant proportion of California's people and structures are subject to potential flooding. Of the statewide population of approximately 34 million (based on the 2000 census), 1.4 million people live within the 100-year floodplain and 7.3 million people live within the 500-year floodplain. With the 2010 population having increased to more than 37 million, even more people are likely to be currently exposed to potential flooding. In addition, about $137 billion and $577 billion in the value of structures and contents are within the 100-year floodplain and 500-year floodplain, respectively. Some level of flooding occurs in almost all parts of the state.
- A large proportion of the state's exposed population and value of structures and contents is in urban regions with high-density populations. For example, the South Coast Hydrologic Region has 3.4 million people and $230 billion in value of structures and contents residing in the 500-year floodplain. In addition, many highly urbanized counties (such as Orange, Santa Clara, San Mateo, and Los Angeles counties) have large numbers of people and a great amount of property exposed in the floodplain. Forty percent of the statewide exposure to the 500-year floodplain in terms of population and structures occurs in just three counties—Orange, Santa Clara, and Los Angeles counties.
- A significant proportion of California's crops are subject to potential flooding. Statewide, $5.4 billion in crop values are exposed to the 100-year floodplain, and $7.5 billion in crop values are exposed to the 500-year floodplain. Twelve counties (San Joaquin, Fresno, Kern, Kings, Merced, Yolo, Tulare, Monterey, Madera, Sutter, Ventura, and Butte counties) have more than $100 million in agricultural crops exposed to both the 100-year and 500-year floodplains. Sacramento County also has more than $100 million in agricultural crops exposed to the 500-year floodplain.
- CNDDB sensitive plant species and sensitive animal species are exposed to potential flooding in many regions of the state. The South Coast Hydrologic Region has the largest number of sensitive plant species exposed in both 100-year and 500-year floodplains. The Sacramento River Hydrologic Region

Statewide Results

100-Year Floodplain (1% annual chance of flooding)

1.4 million people

$136 billion in structures and contents values

$5.4 billion in crop values

500-Year Floodplain (0.2% annual chance of flooding)

7.3 million people

$577 billion in structures and contents values

$7.5 billion in crop values

has the largest number of sensitive animal species exposed in both 100-year and 500-year floodplains.

- The South Coast, San Francisco Bay, and Sacramento River hydrologic regions have the most essential, high potential loss, and lifeline facilities exposed in 500-year floodplains. However, the South Coast region has far more exposure of these types of facilities in the 500-year floodplain than the other regions, with more than 40 percent of the statewide total.
- Exposure of transportation facilities occurs in many parts of the state, with the South Coast, San Francisco Bay, Sacramento River, San Joaquin River, Tulare Lake, and Central Coast hydrologic regions having large numbers exposed in both the 100-year and 500-year floodplains.
- Department of Defense facilities are exposed to potential flooding in many parts of the state. The South Coast Hydrologic Region has the largest number of exposed DoD facilities in both the 100-year and 500-year floodplains.
- Native American tribal land areas are also exposed to potential flooding in many parts of the state. The majority of exposed Native American tribal lands are in the Sacramento River and Colorado River hydrologic regions.

When using these results, it should be noted that the data available to perform the analysis for different parts of the state varied in completeness and quality. For example, structure values within the CVFPP boundary were derived from the data available in the ParcelQuest database, while values from the FEMA HAZUS database were used outside the CVFPP boundary. The study would be improved if floodplains and other data were available for other parts of the state that were of the same quality as what has been developed for the CVFPP boundary.

This analysis of exposure to flood hazard within California provides useful information for making flood management decisions, as follows:

- This analysis shows that significant residual exposure to flooding in California exists. Millions of citizens are subject to inundation, along with homes, businesses, and crops. The relative magnitudes of exposure across the state can be used to help set priorities for more detailed studies to understand better the actual flood risks.
- This analysis shows the locations of areas of greatest urban flooding potential and areas of greatest agricultural flooding potential, which better informs decisions about structuring subsequent detailed studies and formulation of alternatives in those studies.
- It identifies areas that could benefit from enhanced emergency response; these are areas with significant numbers of lives exposed. Enhanced emergency response would provide a better opportunity for evacuation and temporary protection. This analysis will help inform priorities for assessing further those opportunities or for allocating funding for action.

- This analysis shows that a significant portion of California's valuable agricultural land is exposed to flood hazard. Although the detail of this analysis is limited, a major flood (on the order of the 500-year flood) clearly would have significant adverse economic impacts in agricultural regions.
- This analysis shows that sensitive plant and animal species are exposed to flooding. Of the sensitive species exposed, a small percentage is listed by the State of California or by the Federal government as *endangered* or *threatened.*
- It shows that infrastructure critical to continuity of functioning of the State's economy is exposed to hazard. For example, thousands of miles of roadways in the state will be inundated by a 500-year flood, which would limit or stop movement of goods through the state and beyond, with far-reaching impacts. This analysis will help make better decisions about prioritizing risk management studies for those facilities.
- It shows that facilities vital to the national defense are exposed to flooding; a significant flood would impair the ability of those facilities. This analysis will help make better decisions about prioritizing risk management studies for those facilities.

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7.0 References

California Department of Finance (DOF). 2013. *California State Data Center.* "Census 2010." Web site http://www.dof.ca.gov/research/demographic/state_census_data_center/census_2010/. January 15, 2013.

California Department of Fish and Wildlife (CDFW). 2009. *California Natural Diversity Database (CNDDB).* Created by the California Department of Fish and Wildlife, Biogeographic Data Branch, dated April 4, 2009.

California Department of Water Resources (DWR). 2005. *Standard Land Use Legend*.

California Department of Water Resources (DWR). 2006. *Progress on Incorporating Climate Change into Management of California's Water Resources.* July.

California Department of Water Resources (DWR). 2008. *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. October.

California Department of Water Resources (DWR). 2009a. *California Local Flood Response and Recovery Plans: Identification of Flood Hazards*. (Unpublished.) Prepared by David Ford Consulting Engineers and GEI Consulting, Inc.

California Department of Water Resources (DWR). 2009b. *California Water Plan Update 2009.*

California Department of Water Resources (DWR). 2011. *Central Valley Flood Management Planning (CVFMP) Program.* Web site http://www.water.ca.gov/cvfmp/. Accessed October 2012.

California Department of Water Resources (DWR). 2012 *Land Use Survey*. Web site http://www.water.ca.gov/landwateruse/lusrvymain.cfm. Accessed May 2012

California Emergency Management Agency and California Natural Resources Agency (CalEMA and CNR). 2011. *California Climate Adaptation Planning Guide*. Web site http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html. Accessed August 2013.

California Energy Commission (CEC). 2009a. *Projections of Potential Flood Regime Changes in California*. Prepared by M.D. Dettinger, H. Hidalgo, T. Das, D. Cayan, and N. Knowles. CEC-500-2009-050-D.

California Energy Commission (CEC). 2009b. *The Impacts of Sea-Level Rise on the California Coast*. Final Paper. Prepared by Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute. California Climate Change Center. CEC-500-2009-024-F. May.

California Energy Commission (CEC). 2012. *Coastal Flooding-Potential Projections: 2000-2100*. Prepared by Scripps Institution of Oceanography. CEC-500-2012-011.

Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT). 2013. *State of California Sea-Level Rise Interim Guidance Document*. Web site http://www.opc.ca.gov/2013/04/update-to-the-sea-level-rise-guidance-document/. Accessed August 2013.

Committee on Sea Level Rise in California, Oregon, and Washington; Board on Earth Sciences and Resources; Ocean Studies Board; Division on Earth and Life Studies; and National Research Council. 2012. *Sea Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future*. Washington, D.C.: The National Academies Press. Web site http://www.nap.edu/catalog.php?record_id=13389. Accessed August 2013.

Das, T., M.D. Dettinger, D.R. Cayan, and H.G. Hidalgo. 2011. "Potential Increase in Floods in California's Sierra Nevada under Future Climate Projections." *Climatic Change*. DOI 10.1007/s10584-011-0298-z.

Dettinger, M.D. 2011. "Climate change, atmospheric rivers, and floods in California: a multi-model analysis of storm frequency and magnitude changes." *J. Amer. Water Resources Assoc.* Pp. 514-523.

Environmental Systems Research Institute (ESRI). 2008. *National Atlas of the United States and the United States Geological Survey*. April 1.

Environmental Systems Research Institute (ESRI). 2010. *National Atlas of the United States and the United States Geological Survey*. June 30.

Federal Emergency Management Agency (FEMA). 2011. *HAZUS MR5 Flood Model Technical Reference Manual*. January 18. Web site http://www.fema.gov/library/viewRecord.do?id=4454.

Federal Emergency Management Agency (FEMA). 2012. *Map Service Center*. Used for Flood Insurance Rate Map (FIRM) panels. Accessed January 2012.

Fissekis, A. 2008. "Climate Change Effects on the Sacramento Basin's Flood Control Projects." Master of Science Thesis. Department of Civil and Environmental Engineering, University of California – Davis. Pp. 150.

Florsheim, J.L., and M.D. Dettinger. 2007. "Climate and Floods Still Govern California Levee Breaks." *Geophysical Research Letters*. Vol. 34, L22403. DOI:10.1029/2007GL031702.

Hanak and Lund. 2008. *Adapting California's Water Management to Climate Change.* Public Policy Institute of California

Heberger, M., H. Cooley, P. Herrera, P. Gleick, and E. Moore. 2011. "Potential Impacts of Increased Coastal Flooding in California Due to Sea-Level Rise." *Climatic Change*. DOI 10.1007/s10584-011-0308-1.

Knowles, N. 2010. "Potential Inundation due to Rising Sea Levels in the San Francisco Bay Region." *San Francisco Estuary and Watershed Science.* May.

Knox, J.C. 1993. "Large Increases in Flood Magnitude in Response to Modest Changes in Climate." *Nature*, Vol. 361, pp. 430 – 432. DOI:10.1038/361430a0. February 4.

Miller, N.L., K.E. Bashford, and E. Strem. 2003. "Potential Impacts of Climate Change on California Hydrology." *J. Amer. Water Resources Assoc.* Pp. 771-784.

Roos, M. 2005. "Accounting for Climate Change." *California Water Plan Update 2005. Volume 4 – Reference Guide.* Pp. 4.611 – 4.625.

United States Army Corps of Engineers (USACE). 2002. *Sacramento and San Joaquin River Basins, California, Comprehensive Study Interim Report*. December.

United States Department of Agriculture (USDA). 2010. Price indexes released by the National Agricultural Statistics Service, Agricultural Statistics Board of the USDA. October 29. Web site http://usda01.library.cornell.edu/usda/nass/AgriPric//2010s/2010/AgriPric-10-29-2010_new_format.pdf. Accessed January 11, 2012.

United States Environmental Protection Agency and California Department of Water Resources (EPA and DWR). 2011. *Climate Change Handbook for Regional Water Planning*. Web site http://www.water.ca.gov/climatechange/CCHandbook.cfm. Accessed August 2013.

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STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

UNITED STATES ARMY CORPS OF ENGINEERS
FLOOD PLAIN MANAGEMENT SERVICES PROGRAM

The complete report, *California's Flood Future: Recommendations for Managing the State's Flood Risk*, including technical attachments and other supporting information is available for review at:

http://www.water.ca.gov/SFMP